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Wetland Buffers:

Use and Effectiveness

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WETLAND BUFFERS: Use and Effectiveness

U.S. DEPARTMENT OF COMMERCE NOAA
COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

Andrew J. Castelle[1], Catherine Conolly[1], Michael Emers[1], Eric D. Metz[2], Susan Meyer[2], Michael Witter[2], Susan Mauermann[3], Terrell Erickson[3], Sarah S. Cooke[4]

[1]Adolfson Associates, Inc., Edmonds, WA
[2]W&H Pacific, Inc., Bellevue, WA
[3]Washington State Department of Ecology, WA
[4]Pentec Environmental, Edmonds, WA

for

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EXECUTIVE SUMMARY

This report was developed to assist efforts by Washington State agencies and local governments developing policies and standards for wetlands protection. The report summarizes and evaluates scientific literature, an agency survey, and a recent field study on wetland buffer use and effectiveness. Published literature was obtained from several sources and contains information from throughout the country on the concept of wetland buffers, their important functions, effective buffer widths, and buffer determination models. The agency survey reviewed buffer requirements of several states throughout the U.S. and for counties and cities in Washington. The field study reviewed the current state of buffers at several sites in King and Snohomish counties.

Scientific Literature Review

Wetland buffers are areas that surround a wetland and reduce adverse impacts to wetland functions and values from adjacent development. The literature indicates that buffers reduce wetland impacts by moderating the effects of stormwater runoff including stabilizing soil to prevent erosion; filtering suspended solids, nutrients, and harmful or toxic substances; and moderating water level fluctuations. Buffers also provide essential habitat for wetland-associated species for use in feeding, roosting, breeding and rearing of young, and cover for safety, mobility, and thermal protection. Finally, buffers reduce the adverse impacts of human disturbance on wetland habitats including blocking noise and glare; reducing sedimentation and nutrient input; reducing direct human disturbance from dumped debris, cut vegetation, and trampling; and providing visual separation. Wetland buffers are essential for wetlands protection.

Scientists generally agree that appropriate buffer widths are based on several variables, including:

- existing wetland functions, values, and sensitivity to disturbance;
- buffer characteristics;
- land use impacts; and
- desired buffer functions.

Wetland functions, values, and sensitivity are attributes that will influence the necessary level of protection for a wetland. Those systems which are extremely sensitive or have important functions will require larger buffers to protect them from disturbances that may be of lesser threat to a different site. Where wetland systems are rare, or irreplaceable (e.g., high quality estuarine wetlands, mature swamps, bogs), greater buffer widths will ensure a lower risk of disturbance.

Buffer characteristics influence their ability to reduce adverse effects of development, most importantly in relationship to slope and vegetative cover. Buffers with dense vegetative cover on slopes less than 15% are most effective for water quality functions. Dense shrub or forested vegetation with steep slopes provide the greatest protection from direct human disturbance. Appropriate vegetation for wildlife habitat depends on wildlife species present in the wetland and buffer. Effectiveness is also influenced by ownership of the buffer.

Land uses with significant construction and post-construction impacts need larger buffers. Construction impacts include erosion and sedimentation, debris disposal, vegetation removal, and noise. Post-construction impacts are variable depending on the land use, but residential land use, in particular, can have significant impacts. Residential land use is associated with yard maintenance debris, domestic animal predation, removal of vegetation, and trampling. Wetland areas and their buffers should not be included in residential lots.

Appropriate buffer widths vary according to the desired buffer function(s). Temperature moderation, for example, will require smaller buffer widths than some wildlife habitat or water quality functions. Buffer widths for wildlife may be generalized, but specific habitat needs of wildlife species depend on individual habitat requirements.

Buffer effectiveness increases with buffer width. As buffer width increases, the effectiveness of removing sediments, nutrients, bacteria, and other pollutants from surface water runoff increases. One study found that for incrementally greater sediment removal efficiency (e.g., from 90 to 95%), disproportionately larger buffer width increases are required (e.g., from 100 to 200 feet). As buffer width increases, direct human impacts, such as dumped debris, cut or burned vegetation, fill areas, and trampled vegetation will decrease. As buffer width increases, the numbers and types of wetland-dependent and wetland-related wildlife, that can depend on the wetland and buffer for essential life needs, increases.

In western Washington, wetlands with important wildlife functions should have 200 to 300-foot buffers depending on adjacent land use. In eastern Washington, wetlands with important wildlife functions should have 100 to 200-foot buffers depending on adjacent land use. To retain wetland-dependent wildlife in important wildlife areas, buffers need to retain plant structure for a minimum of 200 to 300 feet beyond the wetland. This is especially important where open water is a component of the wetland or where the wetland has heavy use by migratory birds or provides feeding for heron. The size needed would depend upon disturbance from adjacent land use and wetland resources involved. Priority species may need even larger buffers to prevent their loss due to disturbance or isolation of subpopulations.

Buffer widths effective in preventing significant water quality impacts to wetlands are generally 100 feet or greater. Sensitive wetland systems will require greater distances and degraded systems with low habitat value will require less. The literature indicates effective buffers for water quality range from 12 to 860 feet depending on the type of disturbance (e.g., feedlot, silviculture) and the measure of effectiveness utilized by the author. For those studies that measured effectiveness according to removal efficiency, findings ranged from 50 to 92% removal in ranges of 62 to 288 feet. Studies that measured effectiveness according to environmental indicators such as levels of benthic invertebrates and salmonid egg development in the receiving water generally found that 98-foot buffers adjacent to streams were effective. These latter buffer distances may be conservative for wetlands, where lower water velocities and presence of vegetation result in increased sediment deposition and accumulation.

Studies indicate that buffers from 50 to 150 feet are necessary to protect a wetland from direct human disturbance in the form of human encroachment (e.g., trampling, debris). The appropriate width to prevent direct human disturbance depends on the type of vegetation, the slope, and the adjacent land use. Some wetlands are more sensitive to direct disturbance than others.

Various methods are used for determining buffer widths in a regulatory context. Regulatory agencies often establish a rating system, commonly of three or four categories, assessing a given wetland's functional value, sensitivity, rarity, or other attributes. Accordingly, the amount of protection afforded to each type differs.

Agency Survey

A survey conducted of regulatory requirements for wetland buffers indicated that of 16 states surveyed, ten require wetland buffers and eight incorporate wetlands rating, either adopted or proposed. Of five Washington counties with adopted wetlands protection ordinances, all five require buffers and four utilize wetlands rating systems (the fifth is currently proposing an amendment that incorporates rating). Of 28 identified cities with wetlands protection ordinances, 27 contain specific buffer standards and 20 utilize wetlands rating systems. The one city without specific standards has adopted an interim policy statement for wetlands protection.

Specific buffer requirements vary widely at the state and local level. State buffer requirements range from 0 to 300 feet; Washington county buffer requirements range from 0 to 200 feet; and Washington city buffer requirements range from 0 to 300 feet.

Field Study

A field analysis of the current state of buffers in King and Snohomish counties found that effectiveness of the buffer was determined by the type of buffer in place, the type of alteration to the buffer and surrounding area, the width of the buffer, the time elapsed from development, and the ownership of the buffer and adjacent wetland.

Buffer function was found to be directly related to the width of the buffer. Ninety-five percent of buffers smaller than 50 feet suffered a direct human impact within the buffer, while only 35% of buffers wider than 50 feet suffered direct human impact. Human impacts to the buffer zone resulted in increased impact on the wetland by noise, physical disturbance of foraging and nesting areas, and dumping refuse and yard waste. Overall, large buffers reduced the degree of changes in water quality, sediment load, and the quantity of water entering the adjacent wetland. As a rule, buffers were subjected to a reduction in size over time. Of 21 sites examined, 18 were found to have reduced buffer zones within one to eight years following establishment.

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PREFACE

Three significant developments relating to wetlands protection in Washington State occurred in 1990 and 1991. The first was the state legislature's adoption of the 1990 Growth Management Act that requires local governments to protect critical areas including wetlands. The second was Governor Booth Gardner's issuance of an Executive Order for wetlands protection. The third was a revision to the 1991 Puget Sound Water Quality Management Plan which recommends that local governments in the Puget Sound Basin adopt comprehensive wetlands protection programs to achieve a goal of no-net-loss of wetlands functions and values and a long term increase in wetland quantity and quality.

Washington's Growth Management Act was adopted by the state legislature in the final days of the 1990 legislative session. The provisions of the 1990 statute, as well as amendments adopted in 1991, require local governments throughout the state to identify and protect critical areas including wetlands. Interim development regulations are to be adopted by all jurisdictions no later than March 1992. Final development regulations are to be completed by 1994. Those local governments who have not already adopted regulations for critical area protection are now in various stages of developing their ordinances assisted by the Department of Community Development.

On April 21, 1990, Washington's Governor Booth Gardner issued Executive Order (EO) 90-04, Protection of Wetlands. The EO is directed at both state and local governments with specific requirements for state agencies and recommendations for local governments. All state agencies are required to protect wetlands under existing authorities to the extent legally permissible. Following a task in the EO, the Department of Ecology developed a model wetlands protection ordinance to provide guidance to local governments. The model ordinance was released in September 1990 and will be amended in the future to incorporate new information.

In the summer of 1991, the Puget Sound Water Quality Authority modified the wetlands protection element (W-4.1) of the 1991 Puget Sound Water Quality Management Plan. The modified element recommends local adoption of a comprehensive approach to wetlands protection using both regulatory and non-regulatory tools. The comprehensive approach is intended to complement the provisions of the Growth Management Act. The Plan amendments recommend that local development regulations address several elements, including wetland buffers. The amendments refer to Ecology's model ordinance for technical guidance on wetlands protection standards.

Each of these three actions has brought into focus the need for technical information upon which to base wetlands protection policies and standards. During the development of wetlands protection policies and regulations, including the accompanying public deliberation, information is sought on both the scientific basis for wetlands protection standards and on the actions of other regulatory decision-makers.

I. INTRODUCTION

This report was developed to assist efforts by the Washington State Department of Ecology (Ecology), other Washington State agencies, and local governments to develop policies and standards for wetlands protection within existing authorities. Specifically, the report summarizes and assesses information related to wetland buffer use and effectiveness.

The report is organized into four sections accompanied by an executive summary, references, and appendices. The sections include:

- introductory information;
- a review of the existing literature;
- an agency survey of existing regulatory requirements for buffers; and
- conclusions drawn from the literature review and agency survey.

Appendix A presents the results of a field study that provides a post-construction evaluation of the effectiveness of required wetland buffers in protecting wetlands from adverse impacts. Several local projects in King and Snohomish counties were assessed to determine the effectiveness of buffers that were required for development projects adjacent to wetlands.

A companion document entitled Wetland Buffers: An Annotated Bibliography is also available.

II. SCIENTIFIC LITERATURE REVIEW

The scientific literature review is a compilation of the findings of a literature search for information on wetland buffers. A general discussion of the concept of buffers is followed by background information on wetlands buffers and their important functions. Research on recommended buffer widths and buffer determination models is presented.

Information was obtained from a review of published literature as well as from oral and written personal communications. Sources of information included computer search programs, on-line library collections, existing bibliographies, research centers, federal and state agencies, county and city planning departments, professional organizations, environmental organizations, and individuals. A specific list of information sources for this section is listed in Appendix B.

Buffers and Setbacks in Land Use Planning

Our present landscape is a mosaic of developed lands and natural areas, forests and fields, wetlands, and uplands. Expanding human use within the landscape presents a difficult problem to the community and to decision makers: how best to fit the pieces of this mosaic together. Such long-range planning is further complicated by the knowledge that some land uses are incompatible in close proximity to one another.

Designating buffer areas between zones of incompatible land uses has been a common regulatory mechanism for minimizing environmental as well as other physical impacts. In diverse situations ranging from buffer zones around power plants, to tree-lined streets, buffers are employed to lessen the impact of one activity on another. In general, as the level of activity or potential for conflict increases, the width of the buffer needed to minimize conflict between the two land uses will increase proportionally (Brown and Schaefer, 1987). For example, the level of noise, light, temperature, and activity are dramatically higher in developed areas than in natural areas, and the border between developed and natural areas is frequently characterized by "overflows" of these disturbances from the developed land to the undeveloped. These "overflows" may take many forms: subsurface and surface water flow; increased sedimentation; atmospheric pollution; increases in noise and temperature; the introduction of toxins, bacteria, and viruses; more frequent, extensive, and intensive physical disturbances; and the introduction of non-native plant and animal species. Buffer zones are used to protect natural areas such as streams, shorelines, steep slopes, and wetlands from these impacts.

Wetland Buffers

Wetlands are among the most valuable and complex ecosystems on earth. They provide many functions and values to society, including flood control, ground water recharge and discharge, water quality improvement, shoreline stabilization, fish and wildlife habitat, recreational and educational opportunities, and aesthetic values (Smardon, 1978; Williams and Dodd, 1978; Adamus and Stockwell, 1983; Roman and Good, 1983; Brown, 1985).

Until recently, the complexity and importance of wetlands were not widely known, and accordingly, wetlands protection was non-existent or ineffective. Land use strategies in the past frequently encouraged the filling of wetlands, calling it "reclamation," and granted title to anyone who would fill the land. More recently, however, wetlands have been recognized as ecologically and economically valuable. Federal, state, and local governments have responded by enacting laws and developing programs to protect the important values of wetlands recognized by society.

Many wetlands managers believe that the most effective means of stemming the loss of wetlands is avoiding and minimizing adverse impacts of development from the outset (Shisler, 1987). This includes both impacts originating within the wetland perimeter as well as impacts originating adjacent to the wetlands. Uses and development adjacent to wetlands can negatively affect wetland systems through increased runoff (Harris and Marshall, 1963); sedimentation (Darnell, 1976); introduction of chemical and thermal pollutants (Ehrenfeld, 1983); diversion of water supply; introduction of invasive and exotic species; and reduced populations of wetland-dependent species (Zeigler, 1990). The area immediately upland of the wetland boundary is important as a seed reservoir, as habitat for aquatic and wetland-dependent wildlife species, and as a refuge to wildlife during periods of high water (Brown and Schaefer, 1987).

One method of reducing the impacts of development upon adjacent wetlands is to provide a buffer around the wetland. Wetland buffers are those areas that surround a wetland and reduce adverse impacts to the wetland functions and values from adjacent development. Wetland buffers can include both upland and aquatic areas contiguous with a wetland edge, however, the focus of this study is on vegetated upland buffers.

Wetland Buffer Functions

Wetland health can be measured in terms of water quality, hydrology, and fish, wildlife and plant species diversity and abundance. The protective functions provided by wetland buffers can be described under these same parameters.

Water Quality

Wetlands are generally located in low areas of the landscape, causing them to be particularly susceptible to sediment loading from upland sources and to erosional scouring that results from increased water velocities from mismanaged upland surface waters (Brown and Schaefer, 1987). Vegetated wetland buffers function to reduce adverse impacts to water quality by controlling the severity of soil erosion and removing a variety of pollutants from stormwater runoff (Shisler et al., 1987).

Soil erosion is reduced within buffers as vegetation and organic debris shields the soil from the impact of rain and binds soil particles with root materials. Vegetation acts as an obstruction to water flow thereby decreasing water velocities, allowing infiltration, and reducing the erosion potential of stormwater runoff. As a physical barrier to flowing water, vegetation also traps sediments and other insoluble pollutants. The proper functioning of a buffer zone depends in great part on its ability to resist channelization (Broderson, 1973). If the majority of stormwater moving through the buffer does so as sheet flow, the rate of flow is significantly slower, and the residence time of the water in the buffer is increased, allowing more time for settling of water-borne sediments and infiltration. In addition, the root systems of the buffer vegetation aid in the maintenance of soil structure and bank stability (Broderson, 1973).

Soluble nutrients and pollutants are also removed or transformed by the soils, bacteria, and plants in wetland buffers (EPA, 1988). The uptake of dissolved heavy metals and large amounts of nutrients by plants has been well-documented (Murdoch and Capobianco, 1979; Shisler et al., 1987; Gallagher and Kibby, 1980). For example, Murdoch and Capobianco (1979) found that *Glyceria grandis*, a wetland grass, took up 80% of the available phosphorus, and also took up significant quantities of lead, zinc, and chromium. Gallagher and Kibby (1980) found that salt marsh species such as *Carex lyngbyei* (Lyngbi's sedge), *Salicornia virginiana* (pickleweed), *Juncus balticus* (Baltic rush), and *Potentilla pacifica* (Pacific silverweed) accumulated copper, chromium, iron, manganese, strontium, lead, and zinc.

Vegetation scatters sunlight and provides shade, reducing water temperature in the summer, limiting nuisance algae growth, and reducing the release of nutrients from the sediment (Karr, 1978).

Hydrology

Large, sudden fluctuations in wetland water levels often destroy wetland vegetation, particularly along the wetland edge (Clark, 1977). Where wetland vegetation is weakened or destroyed by periods of drought or flooding, native plants give way to weedy, invasive species, invertebrate communities are altered, and wildlife species dependent on these food sources disappear. Increased water level fluctuations caused by increased urbanization have been found to be a major threat to remaining wetlands in the Puget Sound Region, with potential effects on plant succession, habitat, and breeding conditions (Stockdale, 1991).

Wetland buffers play a role in moderating water level fluctuations. Vegetation impedes the flow of runoff and allows it to percolate into the ground. The soil then yields this water to the wetland over an extended period of time, resulting in stable, natural ecosystems. Vegetation also produces litter which increases the humus content of the soil and increase adsorption and infiltration. It also protects other soil properties that are important to infiltration capacity. By intercepting intense rainfall, vegetation preserves soil composition so that infiltration is not impaired (Dunne, 1978).

Bertulli (1981) concluded from his study of a southern Ontario, Canada watershed that adjacent forest vegetation and litter lowered stream flow from 388 to 207 inches in a 100-year flood event. It should be noted, however, that when a catchment area for a wetland has been urbanized and the natural infiltration system has been disrupted, the role of buffers in reducing abnormal water level fluctuations is less significant.

Fish and Wildlife Habitat

The vegetated uplands adjacent to wetlands are considered to be one of the richest zones for aquatic organisms, mammals, and birds (Clark, 1977; Williams and Dodd, 1978). Wetland buffers provide essential habitat for wetland-associated species. In Washington State, 85% of the terrestrial vertebrate species use wetlands and/or their buffers; 359 of 414 species in western Washington (Brown, 1985), and 320 of 378 species in eastern Washington (Thomas, 1979). In Washington, stream buffers and riparian areas provide essential habitat for 68 species of mammals, birds, amphibians, and reptiles. One hundred and three species are more numerous in riparian ecosystems or use them more heavily than upland habitat (Riparian Habitat Technical

Committee, 1985). In western Washington and Oregon, 236 animal species are reported to use coastal, riparian, or wetland communities as their primary breeding or feeding habitats. One hundred and twenty-one species of animals use both aquatic systems and associated uplands for primary breeding or feeding habitat. One hundred and six species use upland edges associated with aquatic systems as primary breeding and feeding habitats (Brown, 1985). This increased use of riparian and other transitional areas demonstrates the concept of "edge effect," a term first coined by Leopold (1933), who proposed that species numbers of both plants and animals increase at edges, due to overlap from adjacent habitats and to creation of unique edge-habitat niches. Such edges are the location of increased wildlife use including feeding, roosting, breeding and rearing of young, and cover for safety, mobility, and thermal protection (Ranney et al., 1981). Naturally vegetated wetland buffers frequently provide vertical as well as horizontal edges that provide ground, shrub, and tree canopy cover (Zeigler, pers. comm., February, 1992).

Often birds and animals that are considered to be wetland-dependent species have essential life needs that can only be met in the adjacent upland buffer (Naiman, 1988, WDW [Appendix C, this report]). These life needs include food, water, shelter from climatic extremes and predators, and structure and cover for reproduction and rearing of young. Waterfowl feed primarily in wetlands but most species nest on dry ground to avoid flooding their nest (WDW, [Appendix C, this report]). Species such as wood ducks, great blue herons, pileated woodpeckers, and ospreys require large trees for nesting. While amphibians, such as the Pacific chorus frog, spend only a short portion of their life span actually in a wetland, they cannot complete their life cycle without one. Many wetland-associated mammals, such as mink and river otters, feed in wetlands, but breed and raise their young in the buffer (Zeigler, 1990). These animals must burrow above the high water mark to avoid inundation of their burrows, which means that they spend significant portions of their lives in the buffer.

Wetland buffers are also important for wetland-related wildlife: animals that concentrate near wetlands but are not necessarily wetland-dependent. The Department of Wildlife (Appendix C, this report) notes that "lush and divergent vegetation in wetland buffers provide food and cover for many species ranging from large mammals, such as deer and elk, to small ones, such as voles and shrews. These areas are used for rearing of young."

Wildlife species have varying spatial requirements to maintain viable populations for survival. Buffers provide an area where animals have needed separation and interspersion to reduce competition and maintain populations (WDW [Appendix C, this report]). Habitat alterations and land use changes adjacent to wetlands can affect wetland-dependent wildlife populations by fragmenting habitat to non-functional sizes and shapes and by introducing disturbance factors above the tolerance levels of some species (Brown and Schaefer, 1987). In 1916, Dice reported that along the Touchet River in southeastern Washington, the natural vegetated buffer was about a quarter mile from the stream. He noted that where the tall cottonwood and shrubby understory had not been disturbed by man, it provided excellent refuges for birds and mammals. Today, the average width of the riparian vegetation is about 50 feet and species that have been totally eliminated or greatly reduced in number since Dice's time include sandhill crane, bobwhite quail (bobwhite), sparrow hawk (American kestrel), Lewis' woodpecker, chipping sparrow, black-headed grosbeak, warbling vireo, Macgillivray warbler, redstart, and long-tailed chickadee (black-capped chickadee) (Mudd, 1975). Washington Department of Wildlife (Appendix C, this report) cited Foster et al., 1984, who found that grazing next to wetlands in the Columbia Basin removed buffer vegetation and reduced waterfowl production by 50%.

Particularly in urban environments where isolated wetlands and riparian wetlands often afford much of the greenspace and wildlife habitat, the use of buffer zones as travel corridors is critical. The vegetated buffer allows animals and birds to move through the urban landscape with some protection from humans and domestic animals. These wildlife corridors have become increasingly important to wildlife with the continuing development of the natural landscape into smaller and smaller isolated units. Corridors effectively increase the size of the habitat area and its ability to maintain viable wildlife populations.

Riparian buffers maintain fish habitat by providing shade, keeping water temperature low enough in the summer to retain dissolved oxygen to support fish and to prevent lethal low temperatures in winter. Streamside vegetation provides a food source through leaf litter and insect drop and provides cover through deposition of large organic debris. By decreasing sediment loads, buffers reduce siltation of essential spawning ground and the destruction of aquatic invertebrates that are important fish food sources. Buffers provide bank cover for fish and provide bank stability though the soil binding capacity of root systems and energy dissipation during flood periods (Riparian Habitat Technical Committee, 1985; Young, 1989).

Direct Human Disturbance

Vegetated buffers provide visual separation between wetlands and developed environments, blocking glare and human movement from sensitive wildlife (Young, 1989). Buffers also discourage direct human disturbance within a wetland in the form of dumping debris, cutting vegetation, or trampling. Direct human disturbance affects both the habitat provided by wetlands vegetation and the wildlife species that are dependent on the wetland. Plant loss can result from either direct crushing or the compaction of soil. Plants in wet soils are especially vulnerable to trampling. Compaction of the soil damages roots, decreases soil water retention, lessens seed germination and seedling survival, and promotes the survival of more aggressive weedy species. As cover is reduced by trampling, for example, wildlife species that depend on the cover or food provided by the vegetation decrease. All wildlife respond to human activities but the intensity and duration of the response varies with life-cycle stage and the affected species. Disturbance at breeding and nesting time can lead to reduced populations caused by loss of eggs and/or young to predation or injury following abandonment by the parents. Repeated disturbance during feeding or resting can result in depletion of vital energy stores during flight or other avoidance responses to humans (Josselyn et al., 1989).

Size of Wetland Buffers

The literature review found a number of approaches used to assess the adverse impacts on wetlands from adjacent land uses and to determine what buffer width will be effective in reducing adverse impacts. Some researchers focused on the use of buffers to reduce impacts of specific land uses such as silviculture, agriculture and recreation. These studies and others have examined buffer requirements and effectiveness either holistically or have isolated one or two specific functions in their studies. Researchers have measured buffer effectiveness by using various biological, chemical, and physical components to assess wetland impacts. These studies include monitoring water quality and quantity; examining plant and animal species distribution; monitoring habitat quality and composition; and measuring levels of human use. Each of these approaches gives a portion of the information necessary to make informed decisions about buffer widths.

The width of buffer considered appropriate to protect a wetland from degradation is related to the wetland functions being protected and the buffer functions being provided (Rogers, et al., 1988). Because buffer function is an important factor in determining buffer widths, information from the literature is summarized according to the following functions:

- sediment removal;
- nutrient removal;
- fecal coliform removal;
- temperature moderation;
- human impact deterrence; and
- wetland species distribution and diversity.

Sediment Removal

Sediment removal is recognized as an important function of wetland buffers, not only to protect the wetland from the adverse impacts of increased sediments loads, but because most nutrients are attached (adsorbed) to sediment. Several investigators have researched the width of buffer necessary to reduce sediments. These studies measure effectiveness based on percentage of sediments removed rather than other measures of ecosystem health.

Wong and McCuen (1982) analyzed the ability of vegetated buffers to trap sediment. They found that average particle size, slope, roughness of vegetated cover, and runoff characteristics must be taken into account in determining buffer widths effective to trap a given percentage of sediment in stormwater flow. Using these parameters, they derived an equation to determine effective buffer widths. While small buffers were found to remove small amounts of sediments, these investigators found that the direct relationship between buffer width and percent sediment removal was non-linear and that disproportionately large buffer width increases were required for incrementally greater sediment removal. For example, effective buffer widths approximately doubled (from 100 to 200 feet at 2% slope) when the design criteria increased from 90 to 95% sediment removal. The authors did not address the removal of the soluble components in stormwater. Young et al. (1980) looked at sediment trapping from livestock feedlots and found that an 80-foot vegetated buffer reduced the suspended sediment in the runoff by 92%. Gilliam and Skaggs (1988) found that 50% of the sediment from agricultural fields was deposited in the first 288 feet adjacent to the exit location of the fields. Horner and Mar (1982) found that a 200-foot grassy swale removed 80% of the suspended solids and total recoverable lead.

The effectiveness of buffers at improving water quality adjacent to logging operations was examined by Broderson (1973), Darling et al. (1982), Lynch et al. (1985), and Corbett and Lynch (1985). Broderson studied three watersheds in western Washington (Green River, North Fork Snoqualmie River, and South Fork Tolt River). He noted that buffers will have little or no effect on sediment removal if the sediment-laden waterflows cross the buffers as channelized flow; buffers can only be effective if they resist channelization and maintain overland flow as sheetflow. Broderson found that 50-foot buffers were sufficient for controlling most sedimentation on less than 50% slopes, while steeper slopes required wider buffers. A maximum buffer width of 200 feet was found to be effective even on extremely steep slopes. Furthermore, Broderson recommended that buffer widths be measured not from the top of the streambank, but rather from "visual signs of high water."

Corbett and Lynch (1985), citing research for an earlier paper by Corbett et al. (1978), concluded that a 40-foot buffer may be adequate to protect streams from excessive temperature elevation following logging, but that a zone of 66 to 100 feet may be necessary to buffer the entire ecosystem, especially when steep slopes are encountered and increased runoff with heavy sediment loads are generated.

Darling et al. (1982) assessed an Oregon State University (OSU) formula for protecting streams and wetlands from tree blow-downs and subsequent large debris and sediment incursions into streams and wetlands. This formula included factors, such as slope and horizontal and elevational distances, from the midpoint of the buffer to the top of the nearest major ridge in the direction of the prevailing winds. Additionally, soil stability and antecedent soil moisture were considered. These investigators were primarily interested in buffer stability over time, and concluded that the OSU formula could be successfully applied in Olympic National Forest, Washington. Further, they found that the best-functioning buffers were the most stable, and that buffer stability was in turn enhanced by high percent vegetative cover and dense stands of trees, rather than by sparse vegetation or individual trees protruding above an understory. They did not, however, directly address buffer widths.

Lynch et al. (1985) assessed the success of 98-foot buffer strips between logging activity and wetlands and streams in Pennsylvania. They found that these buffers removed an annual average of approximately 75 to 80% of the suspended sediment in stormwater. Greater sedimentation resulted from forested areas which had been commercially clear-cut and then denuded with an herbicide. Surface flow in these areas tended to be channelized rather than sheetflow, although Lynch et al. (1985) made no recommendations for larger buffers in such areas.

Moring (1982) assessed the effect of sedimentation following logging with and without buffer strips of 30 meters (98 feet). The author found that increased sedimentation from logged, unbuffered, stream banks clogged gravel streambeds and interfered with salmonid egg development. With buffer strips of 98 feet or greater, the salmonid eggs and alevins developed normally.

Both Erman et al. (1977) and Newbold (1980) found that a 98-foot buffer zone was successful in maintaining background levels of benthic invertebrates in streams adjacent to logging activity in a study of California streams.

Nutrient Removal

A number of studies have assessed the use of buffers to control nutrient inputs into wetland and stream surface waters. Vanderholm and Dickey (1978) monitored feedlots exposed to natural levels of rainfall and found buffer widths ranging from 300 (at 0.5% slope) to 860 feet (at 4.0% slope) to be effective in removing 80% of the nutrients, solids, and oxygen-demanding substances from surface runoff through sediment removal and nutrient uptake. Doyle et al. (1977) assessed the effect of forest and grass buffer strips at improving the quality of runoff from manure application. These investigators found that both forested and grass buffers were effective at reducing nitrogen, phosphorus, potassium, and fecal bacteria in 12.5 and 13.1 feet respectively. In addition, grass buffer strips were effective in reducing nitrate and sodium levels. The percentage reduction of these nutrients was not discussed. Lynch et al. (1985) evaluated the utility of vegetated buffers in reducing soluble nutrient levels in runoff from logging operations. They found that a 98-foot buffer reduced nutrient levels in the water to "far below drinking water standards." Wooded riparian buffers in the Maryland coastal region were found to remove as much as 80% of phosphorus and 89% of nitrogen from agricultural runoff, most of it in the first 62.3 feet (Shisler et al., 1987).

Phillips (1989) studied non-point source pollution in North Carolina, and found that the current 75-foot regulatory requirement for estuarine shorelines was inadequate for filtering polluted runoff from typical residential development. Phillips used a hydrologic model that measures the ability of a buffer to detain polluted stormwater. Pollutant removal efficiencies were estimated for biochemical oxygen demand, total nitrogen, and total phosphorus.

A slightly different approach was used by Bingham et al. (1980), who studied pollutant runoff from caged poultry manure. Rather than recommending specific buffer <u>widths</u>, the authors reported that a 1:1 buffer <u>area</u> to waste area ratio was successful in reducing nutrient runoff to background levels for animal waste applications. Overcash et al. (1981) analyzed grass buffer strips as vegetative filters for non-point source pollution from animal waste with a one dimensional model, and also concluded that a 1:1 ratio of buffer area to waste area was sufficient to reduce animal waste concentrations by 90% to 100%.

Lowrance et al. (1984) evaluated the ability of riparian forest vegetation to remove sediment and nutrient discharges from surrounding agroecosystems. They found that nutrient uptake and removal by the soil and vegetation in the upland forested buffer was high and prevented outputs from adjacent disturbances from reaching the stream channels. However, they did not recommend any specific buffer widths.

<u>Fecal Coliform Removal</u>

A fecal coliform reduction model for dairy waste management was developed by Grismer in 1981 and applied to the Tillamook basin in northwestern Oregon. The model considered the effects of precipitation, season, method of waste storage and application, die-off of the bacteria in storage, die-off of the bacteria on the land surface, infiltration of bacteria in the soil profile, soil characteristics, overland transport of bacteria through runoff, and buffer zones. Grismer's model suggested that a 98-foot "clean grass" strip would reduce the concentration of fecal coliform by 60%. Bufferstrips of 118 feet were found to be sufficient in reducing the concentration of nutrients and microorganisms to acceptable levels in feed lot runoff from summer storms (Young et al., 1980).

<u>Temperature Moderation</u>

Forested buffers adjacent to wetlands function to provide cover, thereby helping to maintain lower water temperatures in summer and lessen temperature decreases in winter. The ability of forested buffer strips to maintain lower water temperatures in the summer months has been investigated by several researchers.

Broderson (1973) found that 50-foot buffers provided 85% of the maximum shade for small streams (defined as streams with mean annual discharges of less than five cubic feet per second). Broderson also found that buffer widths along slopes could decrease with increasing tree height. For instance, a stand 200 feet tall on level ground provides shade approximately 90 feet from the trunk during mid-July when temperature problems often occur. If this stand of trees were on a 60% slope, the effective shade width would increase to 150 feet. Shadow length also increases in the summer months with increasing latitude.

Lynch et al. (1985) found that a 98-foot buffer from logging operations maintained water temperatures within 1°C of their former average temperature. Barton et al. (1985) found a strong correlation between maximum water temperatures and buffer length and width for trout streams in southern Ontario, Canada. They derived a regression equation in which buffer dimensions accounted for 90% of the observed temperature variation.

In their study, Brazier and Brown (1973) sought to define the characteristics of buffer strips that were important in shading small streams adjacent to logging. They found that 73 feet was often ample buffer to shade these streams, maintaining pre-logging temperature ranges. They advocated establishing a buffer range that would apply to different situations of slope, exposure, and canopy cover on a case-by-case basis.

Human Impact Deterrence

Buffer zones function to protect wetlands from direct human impact through limiting easy access to the wetland and by blocking the transmittal of human and mechanical noise to the wetland. Direct human impact to wetlands most often consists of refuse dumping, the trampling of vegetation, and noise. Shisler et al. (1987) analyzed 100 sites in coastal New Jersey to evaluate the relationship between buffer width and direct human disturbance to wetlands. The investigators completed a post construction analysis to demonstrate the effectiveness, or lack thereof, of different buffer widths for different land uses. Disturbance came in the form of abandoned or dumped constructions materials, dumped debris, cut or burned vegetation, fill areas, excavation, trampled paths, bulldozed areas, and adjacent residents expanding their property illegally into the wetlands. Shisler found that the adjacent land use type accounted for much of the variation found in the level of human disturbance. In all cases, human disturbance was higher in wetlands adjacent to dense residential or commercial/industrial uses. As a result of their investigation, Shisler et al. recommended that low intensity land uses (agriculture, low density residential, and recreation) maintain buffers of 50, 50, and 100 feet, respectively, for salt marshes, hardwood swamps, and tidal freshwater marshes. For high intensity land uses (high density residential and industrial/commercial), buffers of 100, 100 and 150 feet were recommended. As buffer width increased, direct human disturbance decreased. Disturbance levels were double at sites with narrow buffers (less than 50 feet). Buffers of 100 feet and greater provided significantly more protection and reflected in lower disturbance to the wetlands than did buffers less than 50 feet. Steeply sloping buffers with dense shrub understories provided the greatest protection.

Cooke (Appendix A, this report) studied 21 wetlands in King and Snohomish counties in a post-project evaluation to assess the effectiveness of buffers in protecting wetlands from human disturbances. Efficiency was measured qualitatively, using observations of human caused disturbance to the wetland and buffer to indicate loss of buffer effectiveness. Cooke felt that the effectiveness of a buffer in protecting adjacent wetlands was dependent on:

- intensity of adjacent land use;
- buffer width;
- buffer vegetative cover type; and
- buffer area ownership.

Buffers functioned most effectively when adjacent development was of low intensity; when buffer areas were 50 feet wide or greater and were planted with shrub and/or forested plant communities; and when the buffers were located on land owned by individuals who understood the rationale for establishing buffers, or were on land outside of residential lots. Projects that incorporated the buffer within residential lots resulted in the loss of the natural vegetation community to lawn over time. Buffer functions were found to be reduced most often as a result of decreasing the effective size of the buffer. Nearly all of the buffers that were less than 50 feet wide at the time they were established demonstrated a significant decrease in effective size within a few years; in some instances, degradation was so great that the buffers were effectively eliminated. Fewer than half of the buffers that were originally at least 50 feet wide showed demonstrable degradation.

The ability of vegetated buffers to abate noise has been analyzed by Harris (1985). Harris studied vegetated borders along busy streets, and concluded that the insertion loss per foot through an evergreen vegetated buffer was between 0.2 to 0.3 decibels(A), and a 20-foot wide mature evergreen buffer would provide an insertion loss of approximately 4 to 6 decibels(A). (A loss of 3 to 4.5 decibels(A) corresponds to approximately tripling the distance between the source of noise and the receptor.)

Josselyn et al. (1989) studied the effects of public activities on waterbirds in wetland habitats in the San Francisco Bay region. In measuring bird disturbance responses (usually movement to another location within the site), they found the distance from the human activity causing a disturbance ranged between 50 and 175 feet. The distance varied between species and habitats, with dabbling ducks exhibiting the most sensitivity. The Washington Department of Wildlife (WDW) (Appendix C, this report) concluded that "a person approaching heron or a flock of waterfowl can agitate and flush them even at distances of 200 to 300 feet. This is especially true for grazing waterfowl on shallow wetlands and wet pastures or black brant on open water."

Wetland Species Distribution and Diversity

Often, the health of a particular type of habitat is measured by the presence or abundance of a particular species of plant or animal or by the presence of particular community types called indicators. These indicator species and communities are used to determine the amount or extent of protection that a habitat needs in order to remain viable. Protection afforded to wetlands and streams by buffers has been assessed using various species of birds and animals as indicators.

Milligan (1985) studied bird species distribution in 23 urban wetlands in King County, Washington. She found that bird species diversity, richness, relative abundance, and the breeding numbers were moderately positively correlated with wetland buffer size. Specifically, increases in species diversity were associated with wetland buffer size increases from 50 to 100 to 200 feet. Milligan concluded, however, that wetland size and the amount of wetland edge were more important than buffer size. Her work suggested a minimum 50 feet of buffer for bird habitat preservation. Finally, Milligan noted that larger buffers may be required for wetlands adjacent to high intensity land uses.

The following information is summarized from Buffer Needs of Wetland Wildlife, prepared by the Department of Wildlife and attached as Appendix C to this report.

In herbaceous vegetation next to wetlands, blue-winged teal use select grassy vegetation for establishment of nest sites. They need three acres of upland for each acre of wetland for breeding. The annual loss of untilled upland nesting cover is a major factor contributing to suppressed duck production, regardless of water conditions. Because of conversion of adjacent uplands, teal and gadwall production in Washington state has been significantly reduced (Zeigler, pers. comm., February 1992). Blue-winged teal nests in North Dakota averaged 256 meters from water. Optimum nest cover values are assumed to occur at less than 250 meters from any wetland other than ephemeral wetlands. Great blue herons tolerate human habitation and activities about 100 meters from a foraging area and occasional, slow moving, vehicular traffic about 50 meters from a foraging area.

In shrub vegetation next to wetlands, the beaver use zone includes an area 600 feet from the wetland edge. Trees and shrubs closest to water are used first. A majority of beaver feed within 328 feet of water. In dry environments, 90% of the beaver feed within 100 feet of water. Belted kingfisher broods use shrub cover along water for concealment. Roosts were 30.5 to 61 meters from water.

In either shrub or herbaceous vegetation in buffers, foraging sites within 200 meters of wetlands that contain nest sites are assumed useful for blackbirds. The average distance from gadwall nest sites to water was less than 45.8 meters in several studies of gadwalls, but nests in North Dakota averaged 351 meters from water. Gadwalls typically select the tallest, densest, herbaceous or shrubby vegetation available in which to nest. The majority of lesser scaup nests have been recorded within 10 meters of the water's edge. They have been found up to 0.4 kilometers from water. The most preferred nesting habitat for lesser scaup is assumed to occur when a 50-meter zone surrounding permanently flooded, intermittently exposed, and semipermanent flooded wetlands with 30 to 75% canopy cover of herbaceous vegetation. Lesser scaup most frequently are observed on wetlands with at least half of the shoreline bordered by trees and shrubs.

In forested buffers, the limiting features for wood duck use are open water, marsh or shrubs and snags. They distance from 0 to 1149 feet from water but average 262 feet. Most nests are within 600 feet of water. Beaver feed up to 600 feet from the wetland edge, using trees and shrubs closest to water first. Lesser scaup use forest buffers, nesting up to 165 feet from water in herbaceous layers. Mink use forested buffers within 600 feet from open water. Most use is within 328 feet of the wetland edge. Mink need 75 to 100% forested cover. Den sites in Idaho were placed up to 328 feet from the wetland edge. Pileated woodpeckers nest within 492 feet of water; most nest within 164 feet. Because of impacts caused by timber harvest to the marten populations, WDW management guidelines recommend no harvest within 200 feet of riparian corridors.

McMahon (1983) found that vegetated buffers were important for survival of juvenile coho salmon, both for temperature moderation, cover and increased food supply. Brook trout are also extremely susceptible to elevated temperatures, and Raleigh (1982) recommended a 30-meter (98-foot) buffer width with 50 to 75% midday shade as optimal. Eighty percent of this buffer should be vegetated, for erosion control, for maintaining the undercut bank areas, and for providing essential cover for the trout along the bank. Raleigh et al. (1984) described similar habitat requirements for rainbow trout, and recommended the same size and make-up for buffer areas.

Some researchers have assessed the value of buffers for several species concurrently, and offer general buffer recommendations. Mudd (1975) studied the Touchet River, analyzing current conditions along the river, and the amount of riparian and wetland wildlife habitat that existed. Bird, mammal, and plant species were surveyed, although game species were studied most. Mudd found that a minimum of 75 feet of natural riparian, primarily mature, vegetated buffer promoted optimum wildlife populations for pheasant, quail, mourning dove, and deer.

The WDW (Appendix C, this report) summarizes that:

> "To retain wetland-dependent wildlife in important wildlife areas, buffers need to retain plant structure for a minimum of 200 to 300 feet beyond the wetland. This is especially the case where open water is a component of the wetland or where the wetland has heavy use by migratory birds or provided feeding for heron. The size needed would depend upon disturbance from adjacent land use and resources involved.
>
> Influence of the water table on the landscape and vegetation is often reduced on the eastside of the state with more abrupt wetland-upland edges. Wildlife use tends to be concentrated closer to water in drier climates. Hall (1970) showed more narrow beaver use on streams in eastern California than had been reported in the literature (100 feet vs. 328 feet). Mudd (1975) showed minimum riparian area for maximum pheasant and deer use to be 75 feet in one eastern Washington study.
>
> In western Washington, wetlands with important wildlife functions should have 300-foot upland buffers for intense land uses and 200-foot upland buffers for low intensity land uses. In Eastern Washington, wetlands with important wildlife functions should have 200-foot upland buffers for intense land use and 100-foot buffers for low intensity land uses.
>
> Priority species or especially sensitive animals or wetland systems such as bogs/fens or heritage sites may need even larger buffers around wetlands to prevent their loss to disturbance or isolation of subpopulations or other loss of wetland function or value."

<u>**Wetland Buffer Determination Models and Recommendations**</u>

Washington State agencies and local governments are not the first to consider the question of wetland buffer protection and buffer sizes. Others, most notably in the eastern United States, have researched wetland buffers and provided methods or models for establishing required buffer distances.

State of New Jersey

A wetland buffer delineation method was developed by Rogers, Golden, and Halpern, Inc. (1988) for the New Jersey Department of Environmental Protection for the protection of tidal and non-tidal wetlands of the coastal zone. This method, designed primarily to maintain water quality, is dependent upon three factors: vegetative cover, soil characteristics, and percent slope. The investigators incorporated a modified version of the Manning's Equation (used in hydraulics to relate runoff to a number of slope variables) to graph relationships among: (1) mean runoff velocity; (2) the roughness coefficient of vegetation; (3) vegetation type; (4) percent slope; (5) sediment trap efficiency; (6) sediment particle size; and (7) buffer width.

The New Jersey method resulted in buffer width recommendations that varied from 25 to 645 feet, depending upon buffer vegetative cover type, slope, and degree of development impact. Based upon this method, specific buffer recommendations were made for coastal New Jersey. Three-hundred-foot buffers were recommended around wetlands which are designated as providing habitat for threatened, sensitive, or endangered species, and around those wetlands designated as a wildlife refuge, management area, or sanctuary. They were also recommended between wetlands and any facility that involves hazardous substances or wastes; septic fields, spray fields, or sewage application areas; and mineral extraction activities, including sand and gravel pits. A minimum of 25 feet was recommended for residential development if the buffer is forested, with a minimum 50-foot buffer for shrubby and herbaceous buffers. No buffers were recommended for projects if the site drainage patterns would be completely diverted away from the wetland, before, during, and after construction (such a practice, however, may have adverse impacts on wetland hydrology). The authors emphasized, however, that although no buffers would be needed to protect wetland water quality if all site drainage were diverted, other functions should be evaluated to determine appropriate buffer widths. (Present factors, such as noise attenuation, maintenance of wetland hydrology, and the availability of upland habitat for wildlife, indicate that buffers are important even if water quality is not an issue.) This method also recommended significantly larger buffers (up to twice as large) if a portion of the buffer is unvegetated or impervious. Additional buffer widths of up to 30 feet are recommended depending upon soil characteristics such as organic matter content and soil drainage class.

New Jersey Water Supply Reservoirs

As a part of a comprehensive watershed management project for the State of New Jersey, a parameter based buffer model was developed by Nieswand et al. (1990) for application to all watersheds above water supply intakes or reservoirs. The primary buffer function sought by the model was nearshore water quality protection. Input requirements for the model include a combination of slope, width, and time of travel across the strip. As a result of their study, Nieswand et al. recommended a minimum 300-foot width for terminal reservoirs and their tributaries due to their "critical position." The 300-foot recommendation excludes slopes in excess of 15% and strip impervious surfaces such as roads, where widths should be greater. For non-terminal reservoirs and pumping stations, the recommended buffer was a minimum of 100 feet excluding slopes and impervious surfaces. For perennial streams and lakes, the recommended buffer was a minimum of 50 feet with the same exclusions.

New Jersey Pinelands
Roman and Good (1983 and 1986) developed a model to determine buffer widths for the New Jersey Pinelands Area, a sensitive complex of uplands, wetlands, and aquatic communities in southeast New Jersey. The model evaluated relative wetland quality and relative impacts of development. Relative wetland quality was determined by vegetation, surface water quality, potential for water quality maintenance, wildlife habitat, and socio-cultural values. Relative impact of development was determined by the potential for site specific impacts, the potential for cumulative impacts on a regional basis, and the significance of watershed-wide impacts. The final values assigned during the scoring process determined final buffer requirements ranging from 50 to 300 feet. Prior to any evaluation, however, a determination of the presence of threatened or endangered species is made. If the wetland is known to support such species and is critical to their survival, the wetland is assigned a buffer of 300 feet.

Wekiva Basin, Florida
Brown and Schaefer (1987) derived a formula for the Wekiva Basin, Florida, using four factors to determine the width of buffer zones: (1) the wetland boundary; (2) the erodibility of soils in the zone immediately upland of the wetland boundary; (3) the depth to groundwater in the upland area immediately adjacent to the wetland; and (4) the habitat requirements of aquatic and wetland-dependant wildlife species.

Rather than setting general recommendations, Brown and Schaefer (1987) gave a detailed formula for a case-by-case determination. The method relied first upon accurate wetland delineations and slope and erodibility determinations. Buffer width recommendations ranged from 43 (for a slope of 3% or less and soils with low erodibility) to 87 feet (3% slope and high erodibility). Larger buffers were required if the ground water table is expected to be lowered as a result of development activity. Buffer widths of 78 to 392 feet were recommended for drawdowns of between one and five feet. Another variable in their model was the maintenance of suitable habitat. In some instances, recommended buffer widths exceeded 500 feet for the specific Floridian ecosystem used in this modeling effort. Finally, Brown and Schaefer addressed the use of buffers for noise reduction and concluded that a minimum of 42 feet of forested buffer is adequate, but that this width should increase to 60 feet if the buffer zone is deforested.

Washington Model Wetlands Protection Ordinance
The Model Wetland Protection Ordinance developed by the Washington Department of Ecology as guidance for local government offered a buffer determination method based on wetland rating categories. The rating categories were defined according to functions and values, sensitivity, rarity, and replaceability of the wetland. Recommended buffers were 200 to 300 feet for Category I; 100 to 200 feet for Category II; 50 to 100 feet for Category III; and 25 to 50 feet for Category IV. These buffer widths can be raised or lowered based on specific criteria.

III. AGENCY SURVEY

The agency survey provides a synthesis of existing regulatory requirements for wetland buffers for significant state programs in the nation and key Washington county and city programs. The purpose of the synthesis is twofold. The first is to confirm the methods and standards for buffer widths that have been adopted through legislative processes by regulatory agencies. The second is to evaluate the effectiveness of the buffer standards.

The synthesis of regulations includes information on the overall regulatory program of the state or local government; specific buffer width requirements; wetlands rating[2] or other methods used to establish buffer widths; and the administrative effectiveness of the regulatory program. The adopted buffer requirements for states, counties, and cities are summarized in Table 1.

Rapid changes are occurring in Washington State and the nation in the formulation of growth strategies and wetlands protection programs. Many jurisdictions that do not currently have regulations in place are in the process of drafting them, and some are in the process of amending regulations already in place (e.g., Thurston and Island counties). Information on proposed buffer requirements for Washington counties and cities is generally not provided in the regulatory synthesis, however, it is summarized in Table 2.

The data used in this study were collected in April and May of 1991. Washington State local government data was updated in February 1992. The information was collected primarily by contacting state and local agencies directly and requesting all relevant laws, regulations and guidelines. The Washington State data was updated according to information currently available to Ecology. Personal communications are cited only when the information provided was not contained in an official agency publication. Only those agencies who have adopted specific regulatory programs which cover wetlands have been included in the regulatory synthesis. Table 2, the summary of proposed programs, includes as many programs as the investigators could find; it is not necessarily the exhaustive list and the proposed standards presented are changing rapidly. Information is presented in alphabetical order by jurisdiction.

Background

Any environmental regulatory program, whether it is administered at the federal, state, or local level, may be divided into three basic components: (1) laws, or enabling legislation to grant the necessary power to regulate certain activities in prescribed areas (e.g., Shoreline Management Act and King County Sensitive Area Ordinance); (2) regulations, which implement and interpret the laws and are mandatory (e.g., Washington Administrative Code and Code of Federal Regulations); and (3) guidelines, which are typically non-binding, flexible advice, on how best to bring projects into compliance with applicable laws and regulations.

For at least the last two decades, a major policy objective of federal, state and many local governments has been a consistent approach to wetland regulation based upon the scientific

[2] A wetlands rating system is a process that differentiates wetlands according to specific characteristics or functional attributes. Protective measures can be varied, with the highest levels of protection given to the highest rated wetlands.

information. In November of 1989 the U. S. Army Corps of Engineers and the U. S. Environmental Agency entered into a Memorandum of Agreement (MOA) for determination of mitigation under the Clean Water Act Section 404(b)(1) Guidelines. This MOA clarified the standards for determining "appropriate and practicable" measures to offset unavoidable impacts. These include: 1) avoidance, which does **not** include compensatory mitigation and allows permit issuance only for the least environmentally damaging practicable alternative; 2) minimization, which requires appropriate steps to minimize the adverse impacts through project modifications and permit conditions; and 3) compensatory mitigation, which is allowed only after all appropriate and practicable minimization has been required.

Ecology's Model Wetland Protection Ordinance incorporates the same three-step hierarchy for evaluating proposed projects in wetlands. The ordinance contains a wetlands rating system for establishing required buffer zone widths and compensatory acreage replacement ratios. Such linkage was suggested in 1984 by the Office of Technology Assessment.

The Office of Technology Assessment (OTA) undertook a wetland study in the early 1980s at the request of the Senate Committee on Environment and Public Works and its Subcommittee on Environmental Pollution (OTA, 1984) to address a range of policy options for dealing with wetland use and regulation. One of the policy options articulated in the study is directly applicable to Ecology's current investigations of wetland buffers and compensatory mitigation. OTA found that categorizing wetlands by relative value (low vs. high), combined with a regulatory strategy that would allow the protection of wetlands based upon those categories, would allow regulatory programs to be "tailored" to protect specific types of wetlands (Eric Metz, OTA Wetlands Advisory Panel Member, pers. comm. April 1991). The Environmental Protection Agency is currently considering such a system for regulating wetlands under the Clean Water Act (Reilly, 1991).

Subsequent to the OTA study, The Conservation Foundation convened the National Wetlands Policy Forum to take a broad look at wetland policy, and to recommend ways to better protect and manage wetlands (The Conservation Foundation, 1988). The Forum recommended establishing a national interim goal of achieving no overall net loss of the nation's wetlands base, and a long term goal of increasing the quantity and quality of the nation's wetland resource base. At the present time, these goals are widely accepted by the federal, state, and local governmental regulatory community. The no-net-loss policy goal lies at the heart of every major wetland protection program in the state of Washington, for example, the Puget Sound Water Quality Management Plan, the 2010 Action Agenda, and the Governor's Executive Order for wetlands protection.

In Washington State there are several key wetland regulatory and policy documents guiding local government wetlands protection efforts. Guidelines (Chapter 365-190 WAC, "Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands and Critical Areas") have been adopted by the Department of Community Development for use by local governments in compliance with the Growth Management Act. These guidelines encourage Washington State counties and cities to make their actions consistent with the intent and goals of Executive Orders 89-10 and 90-04 for the protection of wetlands as they existed on September 1, 1990. The guidelines encourage counties and cities to consider Ecology's model ordinance, and to consider the use of a wetland rating system.

The Puget Sound Water Quality Authority has incorporated a wetlands protection element into the 1991 Puget Sound Water Quality Management Plan. One part of this element (W-4.1) recommends local adoption of a comprehensive approach to wetlands protection using both regulatory and non-regulatory tools. The Plan amendments recommend that local regulations address several elements, including wetland buffers. The plan refers to Ecology's model ordinance for guidance on wetlands protection standards.

National Survey of State Programs

At least sixteen states throughout the country utilize existing laws and regulations to protect wetlands. These are summarized below:

CALIFORNIA

Regulatory Program: The California Coastal Act of 1976 contains the only statewide requirements for wetland protection and management, and the Act applies only to wetlands within California's coastal zone. In 1981, the California Coastal Commission adopted a comprehensive set of guidelines for assistance in determining the commission's wetland jurisdiction. The guidelines established permitted uses in wetland areas, provided specific functional criteria for establishing wetland buffers, and provided standards for determining compensatory wetland mitigation. The process of drafting and adopting the interpretive guidelines was long (nearly two years), very controversial, and relied extensively upon expert scientific opinion (Metz and DeLapa, 1980).

To provide a scientific basis for the guidelines, the commission hired Dr. Christopher Onuf, a salt marsh ecologist, to prepare scientifically supportable standards for protecting wetlands from land use impacts (Onuf, 1979). The report issued by Onuf included two case studies assessing actual attempts by local governments to protect and manage wetlands in a manner consistent with California Coastal Act policies. The case studies included the City of Carlsbad's Agua Hedionda Specific Plan for protecting a coastal lagoon, and the City of Santa Barbara's Environmentally Sensitive Draft Report on the Goleta Slough for protecting a coastal slough. In addition, the commission convened a panel of federal and state agency wetland regulatory experts to review Onuf's recommendations. Along with the Onuf report, literature reviews, technical workshops, and informal interviews with scientists were conducted by commission staff, and constituted the basis of the recommendations contained in the guidelines for determining buffer widths. As a result of the firm scientific foundation for the regulatory concepts contained in the guidelines, subsequent commission decisions which relied upon those principals were upheld in court (Metz and Zedler, 1983).

Rating System: Not actually a rating system, the act distinguishes between "wetlands" and "degraded wetlands." Under the act's system, only "degraded" wetlands are candidates for any type of compensatory mitigation. The California State Department of Fish and Game is responsible for determining whether a wetland qualifies as a "degraded" wetland, a determination based in part on whether the wetland "...is so severely degraded and its natural processes so substantially impaired that it is no longer capable of recovering and maintaining a high level of biological productivity without major restoration activities." The "degraded wetland" classification does not affect buffer width.

Buffer Requirements: The act itself does not contain specific requirements for buffer widths. Buffers are determined on a case-by-case basis using standards contained in the guidelines. The general standard contained in the guidelines is a 100-foot buffer. The precise width is determined based upon the functions, values, sensitivities of the wetland in question; and upon the type, scale, and intensity of the development which is proposed adjacent to the wetland.

Administrative Effectiveness of Regulatory Program: The wetland guidelines have now been in place for ten years. In 1986, the Coastal Commission staff convened a wetland task force and completed an internal assessment of the Commission's wetland program and its effectiveness. The effectiveness of wetland buffer requirements has not been assessed. It is not generally known if buffers were provided, as promised. The guidelines have not been revised or amended since they were adopted in 1981, and they have not been followed consistently by the staff or the Commission. This is due, in part, to the fact that there has not been a full-time wetland coordinator position at the agency since 1983 (Jim Raives, California Coastal Commission, pers. comm., April 1991). Consequently, there has been no overall coordination or technical assistance provided in the wetland area during the past seven years.

To help address these problems, the staff is preparing a wetland regulatory training manual to promote consistent wetland policy within the agency. The agency is also considering reinstating the wetland coordinator position. The task force report recommends that the agency adopt a pro-active wetland program designed to educate the public about wetlands, to reduce conflict with fish and wildlife agencies, and to continue to improve the program.

CONNECTICUT

Regulatory Program: The Connecticut Inland Wetlands & Watercourses Act was passed in 1972. This act and subsequent amendments required municipalities to establish inland wetland agencies to carry out the provisions of the act. These agencies are further obliged by the act to prepare "inventories of regulated areas" which are similar in nature to the National Wetland Inventory maps. While delegating this authority to the individual municipalities, the state has not mandated a specific regulatory program. The state Department of Environmental Protection has issued "Model Inland Wetlands and Watercourses Regulations" as a guide to assist in the implementation of municipal inland wetland regulatory programs. The Department of Environmental Protection acts as a technical advisory panel for the individual municipalities.

Rating System: There is no statewide wetland rating system. All wetlands identified on Connecticut Inventory Maps are afforded the same protection under the law.

Buffer Requirements: While no buffer standards exist in Connecticut, approximately 60% of the municipalities have adopted some form of buffers around "regulated areas" (Doug Cooper, Department of Environmental Protection Water Resources Unit, pers. comm., March 1991). These range from 25 to 150 feet and are usually in areas providing significant local habitat functions (R. Palumbo, City of Millford Planning Dept., pers. comm., March 1991).

DELAWARE

Regulatory Program: Delaware regulates wetlands through the Tidal Wetlands Act of 1973, and the Sub Aqueous Law of 1986. The legislation does not contain specific requirements for buffers. For this reason, the Delaware Department of Natural Resources and Environmental Control has developed a new Freshwater Wetlands Act which is currently being reviewed in the legislative process. The proposed bill is based closely on Delaware's Tidal Wetlands Act of 1973. The proposed Freshwater Wetlands Act would include buffer requirements and a five-tier rating system.

Rating System: The proposed rating system is consistent with Ecology's four-tier rating system, the except for Class 5 wetlands which include and are limited to human-made detention facilities and receive minimal protection under the proposed act. In the proposed Freshwater Protection Act, Class 1 and 2 wetlands will be clearly defined on regulatory maps prepared by the Department of Natural Resources and Environmental Control. The project proponent, or developer, is responsible for delineation of Class 3 through 5 wetlands. All other wetlands are regulated as Class 3 wetlands unless specifically reassigned by the department to another class.

Buffer Requirements: Buffer requirements range from up to 300 feet for Class 1 wetlands, and up to 100 feet for Class 2 wetlands. These buffer areas will be included in the jurisdictional maps. Buffers associated with Class 1 wetlands are protected as if they were Class 2 wetlands, and buffers associated with Class 2 wetlands are protected as if they were Class 3 wetlands. The rationale is that wetland acreage will be increased while at the same time discouraging peripheral impacts to significant wetland systems. Other classes of wetlands are assigned buffer designations on a case-by-case basis. For example, significant alteration of a Class 3 wetland may result in the department upgrading that wetland's status to a higher class so it may receive greater protection under the law.

ILLINOIS

Regulatory Program: The Interagency Wetland Policy Act of 1989 is the first piece of wetland protection legislation passed by the State of Illinois. This law establishes a no-net-loss goal for acreage and function and provides for enhancement of existing wetlands by conditioning state funded projects. This act established an Interagency Wetlands Committee to advise the State Department of Conservation in the development of administrative guidelines.

Rating System: No rating system is contemplated as of this writing.

Buffer Requirements: Buffer requirements are not included as an expressed provision in the act.

LOUISIANA

Regulatory program: The State of Louisiana has no statewide wetland protection legislation. The Coastal Zone Management Act of 1990 has enabled the state to regulate land use in wetlands in a portion of southern Louisiana. Wetlands within the Coastal Zone Boundary are regulated by the Department of Natural Resources (DNR). The Coastal Zone Boundary is a political line that limits DNR jurisdiction, it is not ecologically based. Furthermore, only tidally influenced wetlands (fresh or salt water) are covered under the act. This act requires compensatory mitigation for all wetland impacts and establishes the framework for mitigation banking programs. The state DNR is currently drafting detailed rules and regulations relating to mitigation policy and mitigation banking. The Louisiana DNR also has a division responsible for management of the Coastal Restoration Trust Fund. This fund may also be utilized for restoration and creation of wetland areas deemed suitable by the state legislature. This fund is supported by state oil and gas revenues directly.

Rating System: The Habitat Evaluation Procedure (HEP) developed by the U.S. Fish and Wildlife Service is used for determining mitigation bank credits, for monitoring mitigation projects, and for determining proposed impacts. This rating system considers only fish and wildlife habitat in the evaluation and is not used for determining buffers (that are not required--see below).

Buffer Requirements: The entire Coastal Zone is within the flat alluvial delta of the Mississippi River. Land surface elevations vary by only five feet through the entire area. At certain river flows, the entire land area in southern Louisiana is below the level of the river and is only protected from flooding by existing dikes. The entire coastal zone may also classify as wetland under the Federal Interagency Committee's Technical Criteria. Buffers are not considered important or feasible in this situation.

MAINE

Regulatory Program: Wetlands in the State of Maine are regulated by the Natural Resources Protection Act of 1988 (amended in 1990). The act is implemented by the wetland protection rules, developed by the State Department of Environmental Protection in 1990. The rules establish minimum guidelines that all municipalities must adopt and administer. These standards include a regulatory definition of wetlands, and establish three wetland classes with associated buffer requirements.

Rating System: Under Maine's system, Class 1 wetlands are considered most valuable and include rare and unique habitats, species, and functions. Class 2 wetlands are also considered valuable and include floodplains. Class 3 wetlands do not contain any characteristics of a Class 1 or 2 wetland, and include wet meadows and swamps that are not contiguous to any water body. All land meeting technical criteria in the Federal Manual is considered wetland and placed into this classification system. Class 1 and 2 wetlands under Maine's system are similar to Ecology's Category I and II wetlands, respectively. Under Ecology's four-tier rating system, Maine's Class 3 would be divided into two Categories, III and IV.

Buffer Requirements: Class 1 and 2 wetlands are considered sensitive and require buffers. Class 1 wetlands require 100-foot buffers and Class 2 requires 50-foot buffers.

MARYLAND

Regulatory Program: The State of Maryland passed the Non-tidal Wetland Protection act in January of 1989 (based upon The Tidal Wetland Act of 1974). This act contains a no-net-loss policy for the state, and establishes statewide buffer standards. Buffer requirements are taken directly from The Tidal Wetland Act.

Rating System: A two-tier wetland rating system is employed in Maryland, which includes "areas of special state concern," and all other wetlands. A wetland is considered an "area of special state concern" if it provides habitat for rare, threatened, or endangered plants or animals, or contains a unique habitat or plant association within the state boundaries.

Buffer Requirements: Wetlands considered "areas of special state concern" require a 100-foot buffer, while all other wetlands have a mandatory 25-foot buffer.

MICHIGAN

Regulatory Program: The Goemaere-Anderson Wetland Protection Act of 1979 is the primary piece of legislation governing land use in wetlands in the state of Michigan. Administrative rules promulgated in 1988 enable the state Department of Natural Resources (DNR) to comprehensively administer the wetland management program. In August of 1984, this state became the first in the nation to assume 404 program responsibilities from the U.S. Army Corps of Engineers. This program is primarily focused on expediting the permit application process. Built into the assumption rule is a 90-day time limit for permit review. All wetlands contiguous with lakes, streams, or ponds and all isolated wetlands greater than five acres are covered under the state regulatory program.

Rating System: The State has developed its own methodology for wetland identification that relies more heavily on the presence of hydrophytic vegetation than the methodology presented in the Federal Manual. There is no standardized rating system employed in this state. Wetlands are rated individually by DNR staff and are given a ranking based on a state-developed ranking methodology that also utilizes a great deal of subjective habitat and functional determinations.

Buffer Requirements: There are no buffer requirements for the state of Michigan.

MINNESOTA

Regulatory Program: The Wetland Conservation Act of 1991 (H.F. 1) is Minnesota's main statute governing wetland areas. It includes several key elements: (1) requiring the Board of Water and Soil Resources to adopt rules within the next two years (by 1993) to determine the public value of wetlands and to be the basis for assuring adequate wetland replacement; (2) establishing a restoration and compensation program; (3) establishing a no-net-loss goal for the state; and (4) requiring special protection for peatlands.

Rating System The act protects all wetland types and sizes, with some exemptions. Replacement must be restoring or creating wetland areas of at least equal public value for those wetlands on agricultural lands and at a two to one replacement ratio for non-agricultural lands. Calcareous fens are offered total protection (avoidance of all activities). Also, peatlands are offered special protection by designating certain lands as scientific and natural areas. Replacement is not required for those wetlands also receiving a general permit under the federal Clean Water Act; for activities in Type 1 wetlands on agricultural lands, except bottomland hardwood wetlands; and activities in Type 2 wetlands that are two acres or less in size.

Buffer Requirements: There are no buffer requirements for the state of Minnesota.

NEW HAMPSHIRE

Regulatory Program: New Hampshire's enabling legislation for regulating wetlands is its Fill and Dredge in Wetlands law (RSA 482-A). This statute provides the authority for the state's administrative rules that establish the New Hampshire Wetlands Board (Chapter Wt 100 through Wt 800). The board consists of the commissioners and directors of several state departments, as well as county and municipal government representatives. The board has developed and administers wetland protection rules and regulations for the state. Regulated wetlands include fresh water and salt water wetland areas, as defined by the methodology presented in the 1989 Federal Manual for the Identification and Delineation of Wetlands.

Rating System: Freshwater wetlands are divided into 3 general types: bogs, marshes, and swamps. The law incorporates a priority system based on the rarity and difficulty in restoration of the bog or marsh environment. Priority judgement is also based on the location and relative size within the individual watershed. The rules specify certain habitats and functions as being more "valuable" than others. Specifically, bogs are considered to be the most valuable, followed by marshes, and then swamps. Other specific criteria used by the Board when processing permit applications include: (1) the impact on plants, fish, and wildlife, including rare and endangered species; (2) the impact of the proposed project on public commerce and recreation, with special attention to those projects in or over public waters where boating is possible; (3) the extent to which a project interferes with the aesthetic interests of the general public; (4) the impact upon abutting land owners; (5) the benefit of a project to the interests of the general public, including but not limited to streambank improvement, safety, roadway improvement, and recreational improvements; (6) the impact of a proposed project on quality or quantity of water in watersheds or waters that are public water supplies; and (7) the potential of a proposed project to cause or increase flooding.

Buffer Requirements: Wetland areas are rated and, if considered "valuable" by the Board, are protected by a mandatory 100-foot buffer. Tidal areas are automatically considered valuable, and all tidally influenced areas have a 100-foot buffer requirement.

NEW JERSEY

Regulatory Program: The State of New Jersey has three statutes that protect wetlands: (1) the Coastal Zone Management Act of 1970 that regulates land use in all coastal wetlands; (2) the Freshwater Protection Act of 1988 that provides protection for freshwater wetlands statewide; and (3) a statute that governs activities in the New Jersey Pine Barrens.

Rating System: Coastal wetlands are not rated, however, there are three categories for wetlands covered by the Freshwater Protection Act: (1) those with exceptional resource value; (2) those with intermediate resource value; and (3) those with ordinary resource value. Wetlands with exceptional resource value include those which discharge into certain trout production waters or their tributaries and wetlands with habitat for threatened or endangered species. Wetlands of ordinary resource value include certain isolated wetlands, and human-made drainage ditches, swales, or detention facilities. Wetlands of intermediate resource value include those with no exceptional or ordinary attributes.

Buffer Requirements: The Coastal Zone Management Act can provide for up to 300-foot buffers for coastal wetlands. The Freshwater Protection Act provides for protection of "transition areas" based on the rating category. Exceptional resource value wetlands are assigned buffers of 75 to 150 feet; intermediate resource value wetlands are assigned buffers of 25 to 50 feet, and ordinary wetlands receive no buffer. In the New Jersey Pine Barrens, buffers up to 300 feet may be required.

NEW YORK

Regulatory Program: The New York Freshwater Wetlands Act of 1975 is the only statewide wetland legislation. Under the act, the state regulates:

> "...wetlands greater than 12.4 acres in size; wetlands of unusual local significance; and Class 1 wetlands which are at or near a water body used primarily as a water supply."

Delineation of wetland boundaries is primarily based on vegetation indicators. Within the state of New York, the Adirondack Park Agency also regulates wetlands pursuant to the act on park agency land. The park agency requires a permit for any work in wetlands greater than one-half acre in size.

Rating System: Wetlands regulated in the state of New York are placed into one of four Classes. Class distinctions are based on habitat and vegetation associations, as well as value estimates related to flood control and water quality.

Buffer Requirements: Under the Department of Environmental Conservation Program, wetlands meeting the minimum size requirement are afforded a 100-foot buffer (Patricia Rexinger, NY Dept. of Environmental Conservation, pers. comm., March 1991). The Adirondack Park Agency establishes buffer widths on a case-by-case basis. (Ray Curren, Adirondack Park Agency, pers. comm., March 1991).

Administrative Effectiveness of the Regulatory Program: The New York Freshwater Wetlands Law of 1975 was one of the first wetland protection measures initiated by any state. There have been no significant amendments to this statute since its inception.

OREGON

Regulatory Program: Oregon has a state removal/fill law that is administered by the Oregon Division of State Lands (ODSL) (ORS 541.605-541.695). A permit is required for removal from a waterway of 50 cubic yards or more of material from one location in any calendar year, or the filling of a waterway with 50 cubic yards or more of material at any one location at any time. This law also applies to "waters of the state," which include navigable and non-navigable rivers, bays, estuaries, permanent and certain intermittent streams, and salt and freshwater wetlands.

Oregon also has a mitigation law (ORS 541.626) that applies to fill or removal from estuaries. In addition, in 1989 the Oregon Legislature passed Senate Bill 3, which requires a statewide wetland inventory, and calls for the preparation of Wetland Conservation Plans by local governments. Senate Bill 3 is implemented by administrative rules on wetland inventory and wetland conservation plans (ORS 196.668-196.692).

Rating System: ODSL is developing a broader based functional methodology for all wetlands. The goal is to develop a habitat based model, like that described below for estuarine systems, if there is sufficient information for freshwater wetlands.

The administrative rules for estuarine mitigation contain a habitat based model for weighing relative values of selected estuarine habitat types. Two models exist, one for the Columbia River Estuary, and one for all other estuaries. Substrate, salinity regime, and vegetation are evaluated for relative habitat value, but the output is used only for calculating compensatory mitigation, not for determining buffer width. A comparison is made between values lost and values replaced, with the goal of no overall net loss of estuarine surface area, productivity, diversity, or natural habitat areas.

Buffer Requirements: Senate Bill 3 requires buffers but provides no standards. A senior ODSL staff contacted for this survey believes that determining buffer widths must be addressed on a case-by-case basis, and would depend upon the local planning context. Buffer type and width should be determined based upon the adjacent land use proposed, and the position of the wetland in the landscape. ODSL staff do not support the assignment of buffer widths to wetlands based upon a wetland classification system, which is believed to be "too simplistic" of an approach.

PENNSYLVANIA

Regulatory Program: Pennsylvania does not currently have comprehensive wetland protection legislation at the state level. The only existing law that requires wetland protection is the Dam Safety and Encroachments Act of 1979.

Rating System: According to Section 105.17 of the proposed rules for Dam Safety and Waterway Management, which are administered by the Department of Environmental Resources, Pennsylvania rates wetlands using two categories:

> "The existing regulations contain special permitting criteria for projects affecting 'important' wetlands. The Department has determined that all wetlands will be more appropriately regulated through the establishment of two wetlands categories; namely exceptional value wetlands and all other wetlands. Although all wetlands are valuable and subject to the requirements of this chapter, exceptional value wetlands are special wetlands that deserve enhanced protection. Exceptional value wetlands include wetlands that provide habitat for important, threatened or endangered species, and protect water quality."

Buffer Requirements: The act requires that dams be set back 300 feet from "important" wetlands and watercourses. The State Department of Environmental Resources regulations makes it clear that the setback mentioned does not apply to land uses other than dams.

RHODE ISLAND

Regulatory Program: The Rhode Island Freshwater Wetlands Act of 1971 is administered pursuant to the Department of Environmental Management Rules and Regulations (1989). The rules contain jurisdictional definitions and activities requiring permits. Activities included in this permit procedure include wetland fill, as well as water quality and flood water impacts. Buffers are required.

Rating System: The state employs a "Wetland-Wildlife Evaluation Model" as a method for determining affected areas (Models for Assessment of Freshwater Wetlands, University of Massachusetts at Amherst, Publication No. 32). This rating system is applied on a case-by-case basis. The evaluation includes a determination of whether the land is considered "unique" or "valuable." This assessment is based on cultural and biological parameters, including fish and wildlife habitat values. Rhode Island's "Rules and Regulations Governing the Enforcement of the Fresh Water Wetlands Act," March 1981, defines the above terms as follows:

(a) Unique Wetland - The term "Unique Wetland" as used herein shall refer to those wetlands having special ecological or cultural significance within Rhode Island and possessing one or more of the following characteristics:
   1) presence of rare or endangered plants and animals;
   2) presence of plants of unusually high visual quality and infrequent occurrence:
   3) presence of plants or animals at or near the limits of their geographic range;
   4) unusually high production of native waterfowl;
   5) annual use by great numbers of migrating waterfowl, shore birds, marsh birds or wading birds;
   6) "outstanding" wildlife diversity and production as determined by the aforementioned "Wetland-Wildlife Evaluation Model";
   7) presence of outstanding or uncommon geomorphological features;
   8) presence of outstanding archaeological evidence;
   9) availability of reliable scientific information concerning the geological, biological or archaeological history of the wetlands; and
   10) designation as rare, endangered, exemplary or unique by the Rhode Island Natural Heritage Program.

(b) "Valuable Wildlife Habitat" shall refer to:
   1) those marshes, swamps and bogs that are characterized by "high" diversity and production of wildlife, according to the aforementioned "Wetland-Wildlife Evaluation Model," and (2) those rivers and ponds classified by regulation as Category A, B, or C by the DEM Division of Fish and Wildlife.

Buffer Requirements: The Rhode Island Department of Environmental Management maintains maps of designated wetland areas that are regulated. Included on these maps is an additional 50-foot buffer area that is also regulated.

VERMONT

Regulatory Program: The Vermont legislature passed a statewide wetland protection act in 1986. Vermont Wetland Rules, developed by the state's Water Resources Board, were adopted in 1990. The rules apply to all land identified as wetland by methodology presented in the 1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands.

Rating System: Buffer requirements apply to three classes of wetlands. Class determinations are based upon habitat functions and values, as well as open space and aesthetic concerns. According to the wetland rules:

"Class One wetlands are those wetlands that, in and of themselves, based on an evaluation of the functions in Section 5 (i.e., water storage for flood water and storm runoff, surface and groundwater protection, fisheries habitat, wildlife and migratory bird habitat, hydrophytic vegetation habitat, threatened and endangered species habitat, education and research in natural sciences, recreational value and economic benefits, open space and aesthetics, and erosion control through binding and stabilizing the soil), are exceptional or irreplaceable in their contribution to Vermont's natural heritage and are therefore so significant that they merit the highest level of protection under these rules.

Class Two wetlands are those wetlands, other than Class One wetlands, which based on an evaluation of the functions in Section 5, are found to be so significant, either taken alone or in conjunction with other wetlands, that they merit protection under these rules.

Class Three wetlands are those wetlands that have not been determined by the Board to be so significant that they merit protection under these rules either because they have not been evaluated or because when last evaluated were determined not be sufficiently significant to merit protection under these rules."

Vermont's Class One and Two wetlands closely correspond to Ecology's Category I and II in its recommended four-tier rating system. Wetlands considered Class Three in the Vermont system include Ecology's Category III and IV. Class Three wetlands are not protected under Vermont's wetland rules.

Buffer Requirements: Class One and Two wetlands under the Vermont system require buffers of 100 and 50 feet, respectively.

Washington Survey of County Programs

Five counties (Clark, Island, King, Pierce, Snohomish, and Thurston) in Washington State have existing wetlands regulations in place. Of these, King County has by far the most fully-developed program protecting wetlands. Many of the other counties are in the process of developing wetlands programs for compliance with the state's Growth Management Act (GMA) of 1990. Washington's adopted county regulations are as follows:

CLARK

Regulatory Program: Following more than a year of public involvement and development, Clark County adopted a wetlands protection ordinance in February 1992.

Rating System: The ordinance contains a five-tier wetlands rating system. Category V wetlands are typically small, isolated, rural wetlands dominated by invasive species. These are exempt from regulation.

Buffer Requirements: Buffer requirements are complex and provide for a high degree of site-specific flexibility. Standard buffer widths are 300 feet for Category I, 200 feet for Category II, 100 feet for Category III, and 50 feet for Category IV wetlands. Standard buffer widths can be reduced by up to 40%, depending on the quantity of the existing buffer and potential enhancement of the buffer.

Buffer widths for rural zones are reduced by 50% to 150 feet for Category I, 100 feet for Category II, 50 feet for Category III, and 25 feet for Category IV wetlands. In the rural zones, buffer widths cannot be further reduced.

ISLAND

Regulatory Program: Island County was one of the first counties in the state to adopt wetlands protection regulations. In 1984, the county adopted these wetland provisions as an overlay zone within the County's zoning ordinance which includes a wetlands rating system, buffers, and mitigation requirements. Regulated wetlands include those defined under the federal Clean Water Act, with exemptions for smaller wetlands.

Rating System: Island County has a three-tier rating system:

> Category A: Wetlands 1/4 acre or larger with the "presence of a protected species or an outstanding habitat for a protected species" and those with a "predominance of native wetlands species over introduced or non-native wetland species."
>
> Category B: Wetlands that include all marshes, bogs, swamps, and lakes regulated by the Shoreline Management Act and the county's Shoreline Master Program, as well as all other wetlands one acre or larger that exhibit a predominance of non-native wetland plant species. Mitigation sites are included.

Category C: Wetlands created by humans "where no wetland before existed." These wetlands are not regulated.

Buffer Requirements: A 100-foot buffer is required for Category A wetlands; a 25-foot buffer is required for Category B wetlands; and no buffers are required for Category C wetlands. Buffers widths may be modified by the county planning director on a case-by-case basis, and reduction of the buffer may be allowed "to provide a reasonable buildable area for a single family residence or accessory building on a lot legally established prior to the effective date of the ordinance.

Administrative Effectiveness of Regulatory Program: The Board of Island County Commissioners feels that their program is a responsible approach to wetlands protection. They use a two category rating system because of its simplicity yet effectiveness.

KING

Regulatory Program: The King County Sensitive Areas Ordinance (KCSAO) passed by the county council in 1990 is in many ways a pioneering document. This ordinance attempts to define all major environmental areas of public concern, including wetlands, throughout the county. The accompanying map folio to the KCSAO includes all regulated land as it pertains to the KCSAO. Alteration of wetlands and required buffers is not allowed without an appropriate mitigation plan that enhances or protects the wildlife habitat, natural drainage, and/or other valuable functions of wetlands. Delineation is based on the 1989 Federal Manual.

Rating System: The ordinance contains a three-tier rating system for wetlands. The King County Wetland Inventory (1990) of existing wetlands was based on a variety of sources, including National Wetland Inventory and field verification. The inventoried wetlands were rated using distinctions based exclusively on habitat, plant associations and size.

Class 1 wetlands are wetlands assigned the Unique/Outstanding #1 rating in the King County Wetlands Inventory, 1983, or meeting the following criteria: providing habitat for threatened, endangered species; having 40 to 60% permanent open water in dispersed patches with two or more classes of vegetation; being wetlands ten acres or more in size and having three or more wetland classes, one of which is open water; or having rare plants.

Class 2 wetlands are those wetlands assigned Significant #2 rating in the King County Wetlands Inventory, or with the following: greater than one acre in size; equal to or less than one acre in size and having three or more wetland classes; wetlands equal to or less than one acre that have a forested wetland class; and/or the presence of heron rookeries or raptor nesting trees.

Class 3 wetlands are those assigned the Lesser Concern #3 rating in the King County Wetlands Inventory, or inventoried wetlands that are equal to or less than one acre in size, having two or fewer wetland classes.

Buffer Requirements: Alteration of wetlands and required buffers is not allowed without an appropriate mitigation plan that enhances or protects the wildlife habitat, natural drainage, and/or other valuable functions of wetlands. Buffers are established as follows:

Class 1 wetlands:	100 feet
Class 2 wetlands:	50 feet
Class 3 wetlands:	25 feet

Additional buffer requirements may be set by the county in sensitive areas including critical drainage areas, locations of hazardous materials, critical fish and wildlife habitat, landslide or erosion hazard areas adjacent to wetlands, groundwater recharge and discharge, and trail or utility corridors.

Minimum building setbacks of 15 feet are required from the edge of the wetland buffer. Prohibitions on the use of hazardous or toxic substances and pesticides or certain fertilizers in this area may be imposed.

Administrative Effectiveness of the Regulatory Program: The county is finding that dividing the KSAO into two separate documents would ease administration of the program. These documents would include a general policy statement and overview of the program, and an accompanying set of detailed regulations. Experience has shown that the standards contained in the KSAO are complex and affect many departments within the county which has lead to some confusion. Weekly meetings held by county staff are used to formalize interpretations of those KSAO provisions that have needed further definition. Since the KSAO has been enacted in such a short time, it is premature to judge its effectiveness (Cindy Baker, King County KSAO Implementation Coordinator, pers. comm., May 1991).

PIERCE

Regulatory Program: In January 1992, the Pierce County Council adopted Ordinance No. 91-128S3, the Pierce County Wetland Management Regulations. The ordinance requires that by September 1992, the director of Planning and Land Services report to the Council's Planning and Environment Committee on implementation of the ordinance.

Rating System: The ordinance establishes a four-tiered rating system. Category I wetlands are those of exceptional resource value, based on attributes which may not be adequately replicated through creation or restoration. Category II wetlands have significant resource value. Category III wetlands have important resource value based on vegetative diversity. Category IV wetlands are those of ordinary value based on monotypic vegetation and hydrologic isolation.

Buffer Requirements: Buffers range from 25 to 150 feet, based on wetland rating category, with the ability to modify (increase, decrease, or average) buffer widths dependant on specific allowances.

SNOHOMISH

Regulatory Program: On May 30, 1990, Snohomish County Council adopted the Aquatic Resource Protection Program (ARPP), consisting of policies and ordinances for the protection of aquatic resources (Freeman, 1990). A referendum petition placed the ARPP on the November 1990, ballot and it was subsequently suspended. Until early 1991, the ARPP was administered as policy. In early 1991, the Snohomish County Council voted to eliminate the Aquatic Resource Protection Program for use even as a policy document.

Until a new wetlands program is approved, the wetland protection policy in Snohomish County that is currently in operation is contained in the Comprehensive Plan. Through SEPA review, categorizations and buffers are determined based on site-specific information.

Rating System: The county does not employ a wetland rating system at this time, although a three-tiered system was developed for the ARRP.

Buffer Requirements: An average 50-foot buffer is required adjacent to a wetland. The county works with the applicant and determinations are made on a case-by-case basis.

Administrative Effectiveness of the Regulatory Program: The county employs six full-time and two part-time biologists who review wetland issues and permits. The Snohomish County Planning Department and Planning Committee are developing a new wetlands program (Marilyn Freeman, Snohomish County Planning, Pers. Comm., May 1991).

THURSTON

Regulatory Program: The Environmentally Sensitive Areas Chapter of the Thurston Regional Planning Council Comprehensive Plan, completed in 1988, regulates wetlands greater than one acre. Special plans are required for certain developments, and the county can also require "building and development coverage, setbacks, size of lots and development sites, height limits, density limits, restoration of ground cover and vegetation, or other measures for environmental protection." A wetlands map included in the Comprehensive Plan depicts the general outlines of wetland areas in the county. In November 1990, the county drafted revisions to its Environmentally Sensitive Areas chapter.

Rating System: None, although the draft standards include a four-tier rating system.

Buffer Requirements: The county does not require standard buffers adjacent to wetland areas, but using its general wetlands polices established in the Environmentally Sensitive Areas Ordinance, the county may require up to 200-foot buffer on a case-by-case basis. The draft standards use the same buffer zone widths (25 to 300 feet) as the Ecology's model ordinance.

Washington Survey of City Programs

Since the Growth Management Act Guidelines were enacted, many Washington cities have, or are in the process, of developing regulations concerning development in and around wetlands. At least 28 Washington cities now require wetlands protection. The majority of these cities have specific wetland buffer requirements.

ANACORTES

Regulatory Program: The City of Anacortes regulates wetlands through a subsection of the city's Zoning Ordinance No. 1917. This subsection, called "Non-tideland Wetland Protection," applies to all lands in, or within, 25 feet of a non-tidal wetland greater than 10,000 square feet. Non-tidal wetland permits are issued if an activity is determined to be in the public interest, is water-dependent, and meets other detailed requirements.

Rating System: None.

Buffer Requirements: No regulated activity in or within 25 feet of a non-tidal wetland may be conducted without a permit.

BAINBRIDGE

Regulatory Program: The City of Bainbridge adopted a wetlands protection ordinance in February, 1992.

Rating System: Bainbridge has developed a four-tier rating system that is a modification of the Washington State and Puget Sound Wetlands Rating Systems.

Buffer Requirements: Buffers are specified as 150 feet for Category I wetlands, 100 feet for Category II wetlands, 50 feet for Category III wetlands, and 25 feet for Category IV wetlands.

BELLEVUE

Regulatory Program: The City of Bellevue regulates wetlands through the City of Bellevue Land Use Code, the City of Bellevue Comprehensive Plan, and the City of Bellevue Sensitive Areas Notebook. Bellevue's regulated wetlands are defined as follows:

> "Those sensitive areas transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of applying this definition wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is non-soil and is saturated by water or covered by shallow water at some time during the growing season of each year."

Rating System: Wetland buffers are regulated through a rating system that includes Type A, B, and C wetlands. Wetlands are rated according to their relationship to Type A or B riparian corridors and by size (Sensitive Areas Notebook, Section 3.3)..

Buffer Requirements: Type A Wetlands require a 50-foot buffer, and Type B Wetlands require a 25-foot buffer. Type C wetlands are not regulated by the City of Bellevue; however, if a Type C wetland is determined to have certain significant (not defined) functions and values, the city may decide to regulate that wetland and require a buffer (Kim Eggebraten, City of Bellevue, Storm and Surface Water Utility, pers. comm., April 1991). Adjustment of buffers may be possible when required setbacks exceed 50% of area encompassed by the property.

BELLINGHAM

Regulatory Program: After two years and completion of a comprehensive inventory, the City of Bellingham adopted a Wetlands Ordinance in December 1991.

Rating System: The ordinance includes a three-tiered rating system.

Buffer Requirements: Buffers are 100, 50, and 25 feet for Category I, II, and III wetlands, respectively.

BONNEY LAKE

Regulatory Program: The City of Bonney Lake adopted a Sensitive Areas Ordinance in August 1991. The code has a wetlands protection element that regulates wetlands as defined under the federal Clean Water Act and ponds under 20 acres and their submerged aquatic beds. One of the goals of the ordinance is for no-net-loss of wetlands functions and values. Sensitive Areas Permits and special studies are required for wetlands impacts.

Rating System: The city uses Ecology's four-tier rating system. The minimum size for regulation is 5,000 square feet of a Category IV wetland.

Buffer Requirements: Type I wetlands require a 200-foot buffer; Type II require a 100-foot buffer; Type III require a 50-foot buffer; and Type IV require a 25-foot buffer. A 15-foot setback may be required for some projects.

BOTHELL

Regulatory Program: The City of Bothell adopted an interim critical areas ordinance in December 1991.

Rating System: The city's rating system is the same as King County's three-tier system, providing varying regulatory requirements for Categories 1, 2, and 3.

Buffer Requirements: Buffer requirements are established as ranges. They include 75 to 150-foot buffers for Category 1, 50 to 100-foot buffers for Category 2, and 25 to 50-foot buffers for Category 3.

BURLINGTON

Regulatory Program: In August 1991, the City of Burlington adopted interim regulations for critical areas as an addition to the Municipal Code.

Rating System: None.

Buffer Requirements: A minimum 25-foot buffer is required unless a wetlands study, requested by the Planning Director, recommends a greater width.

CAMAS

Regulatory Program: The City of Camas added an environmentally sensitive areas chapter to the zoning code in August 1991. Prior to issuance of a SEPA threshold determination within identified wetlands areas, the applicant is required to submit a wetlands report that serves as the basis for wetlands protection requirements.

Rating System: None.

Buffer Requirements: Buffers are required for all development proposals and activities adjacent to wetlands. The required buffer width will be established by the Planning Director based on information contained in the wetlands report and will generally be 50 feet. However, the buffer may be reduced to 25 feet for wetlands determined to be of low quality and increased to 100 feet for wetlands of higher quality.

DES MOINES

Regulatory Program: Wetlands within the City of Des Moines are subject to the regulations in Ordinance No. 853. All areas considered wetland according to the 1989 Federal Identification and Delineation Manual are regulated within the city limits.

Rating System: A wetland rating system has been developed that assigns each wetland into one of two categories:

> "Significant Wetlands" include the following: (1) any wetland assigned either the Class 1 or Class 2 rating by King County; (2) any wetland showing significant changes since being inventoried; (3) wetlands having any threatened or endangered species; (4) wetlands within a stream corridor greater than or equal to one acre in size having one or more wetland classes; or (5) wetlands within a stream corridor having three or more wetland classes.
>
> "Important Wetlands" are defined as follows: (1) any wetland that has been assigned the Class 3 wetland rating by King County; (2) any rated wetland that has significantly changed conditions since being inventoried; or (3) a collection of wetlands within a stream corridor, which is less than one acre in size having two or fewer wetland classes.

All wetlands are placed into one of these two categories. This two-tier rating system is based on the King County Wetland Inventory.

Buffer Requirements: Buffer standards are based on the two-tier rating system. A significant wetlands require a 100-foot buffer, and important wetlands require a 35-foot buffer. Additional buffers may be required if, for example, rare plant or animal species are present, or a unique wetland exists.

EATONVILLE

Regulatory Program: The city adopted a wetlands protection ordinance in September 1991.

Rating System: Eatonville incorporates Ecology's four-tier rating system in their ordinance.

Buffer Requirements: Required buffer widths are 50 to 100 feet for Category I wetlands, 35 to 50 feet for Category II wetlands, 25 to 35 feet for Category III wetlands, and ten to 25 feet for Category IV wetlands.

ENUMCLAW

Regulatory Program: The City of Enumclaw passed a Critical Areas Ordinance in January 1992 which provides wetlands protection regulations.

Rating System: The city uses Ecology's four-tier rating system.

Buffer Requirements: The buffer requirement for Category I wetlands is 100 feet, for Category II wetlands is 75 feet, for Category III is 50 feet, and for Category IV wetlands is 25 feet. Certain conditions allow buffers to be reduced by a maximum of 25%, or increased.

EVERETT

Regulatory Program: The City of Everett adopted Environmentally Sensitive Area Policies and Zoning Regulations in 1991.

Rating System: The regulations classify wetlands into four categories based on wetland size, wetland class (forested, shrub-scrub), and to some degree, functions, and values.

Buffer Requirements: The regulations include 100, 75, 50, and 25-foot buffers for Categories I through IV.

FEDERAL WAY

Regulatory Program: The Federal Way Zoning Code classifies and regulates wetlands and other sensitive areas. The Zoning Code defines "regulated" wetlands that include any wetland that has been mapped and classified by King County; any other wetland that is functionally related to a mapped wetland; or any wetland, whether or not mapped, that has or is functionally related to a wetland that has any significant or valuable (not defined) functions.

Rating System: None.

Buffer Requirements: All regulated wetlands have a setback requirement of 100 feet. Encroachment into the buffer is permissible under certain, limited circumstances. For example, if a wetland setback area encompassed an entire building lot, and if reasonable use of property could not be attained, buffer encroachment would be allowed, but a mitigation plan would probably be required. These issues are determined on a case-by-case basis (Susan Meyer, Consulting Wetland Specialist to the City of Federal Way, pers. comm., April 1991).

Administrative Effectiveness of the Regulatory Program: Administration of these buffer standards is sometimes difficult due to the lack of clear, consistent comprehensive guidance.

KIRKLAND

Regulatory Program: Chapter 90 in the City of Kirkland Zoning Code contains wetland regulations. The city's definition of "regulated" wetland's is very similar to that which is used by the City of Federal Way (see above).

Rating System: None.

Buffer Requirements: A 50-foot setback is required around all wetlands.

Administrative Effectiveness of the Regulatory Program: The wetlands protection regulations are somewhat difficult to administer because they are open to interpretation (Joan Liebermann-Brill, City of Kirkland Planning Department, pers. comm., March 1991).

LACEY

Regulatory Program: In July 1991, the City of Lacey adopted a Wetlands Protection Ordinance.

Rating System: Lacey uses Ecology's four-tiered rating system with an added "Category V" wetland. Category V criteria are wetlands that do not meet the requirements of Categories I through IV and are Type 2 to 5 waters as defined by the Washington Forest Practice Rules and Regulations. Type 1 waters are specifically excluded from this category.

Buffer Requirements: The City of Lacey's buffer widths are:

Category I:	200 to 300 feet
Category II:	100 to 200 feet
Category III:	50 to 100 feet
Category IV:	25 to 50 feet
Category V:	50 to 200 feet

The city's ordinance includes buffer averaging, criteria for increasing and decreasing buffer width, and a building setback requirement which corresponds to the required yard area setback for the underlying zone.

LYNDEN

Regulatory Program: The City of Lynden passed a Sensitive Areas Ordinance which amended the Municipal Code in September 1991. Within the ordinance, the city declares that there is no land within the city limits which can be considered wetlands, except areas within the shorelines of the city that are protected through the Lynden Shoreline Master Program. There may be wetlands in the urban growth areas that could potentially be annexed by the city, but the ordinance leaves that issue to future consideration.

Rating System: None.

Buffer Requirements: Sensitive area buffers are a minimum of 25 feet and a maximum of 100 feet.

MILTON

Regulatory Program: Milton adopted Ordinance 1148 on August 6, 1991.

Rating System: The ordinance utilizes Ecology's four-tier rating system.

Buffer Requirements: The City of Milton's buffer widths are 200 to 300 feet for Category I wetlands, 100 to 200 feet for Category II wetlands, 50 to 100 feet for Category III wetlands and 25 to 50 feet for Category IV wetlands.

OLYMPIA

Regulatory Program: The City of Olympia adopted amendments to its zoning code in March 1992.

Rating System: The city utilizes Ecology's four-tier rating system.

Buffer Requirements: Required buffer widths are 200 to 300 feet for Category I wetlands, 100 to 200 feet for Category II wetlands, 50 to 100 feet for Category III wetlands and 25 to 50 feet for Category IV wetlands. Provisions are provided to reduce buffer widths if wetland buffers are enhanced.

Administrative Effectiveness of the Regulatory System: The city is revising its Environmentally Sensitive Areas Chapter. The current buffer rating system is seen as inadequate, and will be modified to a system that incorporates wetlands quality in addition to size. The current ordinance effectively prohibits any development within a wetland, and an amended ordinance may allow increased flexibility while assuring protection. Olympia will be utilizing the regional mapping system prepared in 1992 (Steve Morrison, pers. comm., September 1991).

PORT ANGELES

Regulatory Program: In November 1991, the City of Port Angeles adopted their Wetlands Protection Ordinance.

Rating System: The city uses Ecology's four-tier rating system.

Buffer Requirements: The city's buffer widths are 200 to 300 feet for Category I wetlands, 100 to 200 feet for Category II wetlands, 50 to 100 feet for Category III wetlands and 25 to 50 feet for Category IV wetlands.

PUYALLUP

Regulatory Program: On September 3, 1991, the City of Puyallup adopted a new chapter of the Municipal Code entitled Wetlands Protection Regulations.

Rating System: The City of Puyallup has adopted a four-tier rating system that is similar to Ecology's rating system. Category I and II wetlands have no minimum size requirement. Category IV has a 10,000 square foot minimum size requirement, but also includes wetlands less than 5,000 square feet that are a functional part of an interconnected aquatic system containing two or more wetlands.

Buffer Requirements: Category I, II, III, and IV wetlands have 150, 100, 50, and 25-foot minimum buffer widths respectively.

REDMOND

Regulatory Program: The City of Redmond is in the process of adopting a Critical Areas Ordinance that includes a comprehensive wetlands section. Because the development of the Critical Areas Ordinance has taken more time than anticipated, the city adopted an interim wetlands protection ordinance in September 1991. The interim ordinance (Ordinance No. 1649) has no standards and states the following policy:

> "Retain and protect the important biological and hydrological functions of wetlands through conditions on new development to assure no-net-loss of wetland acreage, function, and value in the Redmond Planning area."

Rating System: None.

Buffer Requirements: None.

SEATTLE

Regulatory Program: In October 1990, the City of Seattle adopted interim regulations to protect critical areas. Wetlands reports or additional information for project review may be required by the director to ensure more thorough analysis of alternatives.

Rating System: None.

Buffer Requirements: Required wetland buffers are 25 feet.

SHELTON

Regulatory Program: Not available.

SNOQUALMIE

Regulatory Program: The City of Snoqualmie adopted a sensitive areas chapter into their municipal code in August 1991. Wetlands protection regulations include a three-tier rating system, mitigation requirements, and buffer standards.

Rating System: Snoqualmie's rating system is similar to King County's:

> Class 1 Wetlands - wetlands assigned the unique/outstanding #1 rating in King County's Wetlands Inventory, 1983; or which meet any of the following criteria:
> (1) the presence of species listed by the federal government or state as endangered or threatened, or the presence of critical or outstanding actual habitat for those species; (2) wetlands having 40 to 60% permanent open water in dispersed patches with two or more classes of vegetation; (3) wetlands equal to or greater than 10 acres in size and having three or more wetland classes, one of which is open water; or (4) the presence of one or more plant species on a landform type which do not often occur in King County.
>
> Class 2 Wetlands: wetlands assigned the significant #2 rating in the King County Inventory or any wetlands which meet any of the following criteria (1) wetlands greater than one acre in size; (2) wetlands equal to or less than one acre in size and having three or more wetland classes; (3) wetlands equal to or less than one acre that have a forested wetland class; or (4) the presence of heron rookeries or raptor nesting trees.
>
> Class 3 Wetlands: wetlands assigned the lesser concern #3 rating the King County Inventory, or uninventoried wetlands that are equal to or less than one acre in size and that have two or fewer wetland classes, none of which are a forested wetland class. Isolated wetlands are included in the Class 3 category.

Buffer Requirements: The ordinance requires 100-foot buffers for Class 1 wetlands, 50-foot buffers for Class 2 wetlands, and 25-foot buffers for Class 3 wetlands. In addition, a building setback line of 15 feet is required. There are permitted uses in the buffers and wetland areas, provided mitigation or enhancement plans are approved by the city. Allowed activities include stream crossings, stream relocations, trails in buffer areas, landscaping, utilities in wetland or stream buffer, roads, and other rights of way.

TACOMA

Regulatory Program: In February 1992, the Tacoma City Council adopted a Critical Areas Ordinance that includes wetlands protection.

Rating System: The Tacoma ordinance includes use of Ecology's four-tier rating system.

Buffer Standards: Buffer requirements are 200 feet for Category I wetlands, 100 feet for Category II wetlands, 50 feet for Category III wetlands, and 25 feet for Category IV wetlands.

TUKWILA

Regulatory Program: On June 10, 1991, the City of Tukwila passed a Sensitive Areas Ordinance with wetlands protection regulations.

Rating System: The ordinance uses the King County rating system to establish development standards and criteria.

Buffer Requirements: Buffer widths for wetlands are 100 feet for Type 1, 50 feet for Type 2, and 25 feet for Type 3 wetlands.

TUMWATER

Regulatory Program: In August 1991, the City of Tumwater adopted a Conservation Plan as part of their Comprehensive Land Use Plan. The Plan addresses natural resource lands conservation and critical areas protection, including an element which specifies wetlands regulations.

Rating System: Tumwater incorporates Ecology's four-tier rating system.

Buffer Requirements: Tumwater requires 25 to 300-foot buffers based on wetland category. There are some low intensity uses permitted in the wetland buffer area, for instance: relocation of electric facilities, natural gas, cable, and telephone facilities; and installation or construction in improved road rights-of-way.

WENATCHEE

Regulatory Program: Effective September 1, 1991, the City of Wenatchee passed a Resource Lands and Critical Areas Development Ordinance that includes wetlands regulations.

Rating System: The ordinance incorporates Ecology's four-tier rating system.

Buffer Requirements: Buffer requirements for Category I, II, III and IV wetlands are 250, 150, 75, and 50 feet, respectively. Criteria are provided that allow buffers to be reduced by a maximum of 50% depending on the adjacent conditions.

TABLE 1
Adopted[1] Wetland Buffer Standards

STATE	Buffer Requirement	Rating System	Buffer Range
California	yes	yes	100 feet
Connecticut	no	no	none
Delaware	yes	yes	0 to 300 feet
Illinois	no	no	none
Louisiana	no	yes	none
Maine	yes	yes	25 to 100 feet
Maryland	yes	yes	25 to 100 feet
Michigan	no	no	none
Minnesota	no	no	none
New Hampshire	yes	no	0 to 100 feet
New Jersey	yes	yes	0 to 300 feet
New York	yes	no	0 to 100 feet
Pennsylvania	yes	yes	300 feet
Oregon	no	no	none
Rhode Island	yes	no	50 to 100 feet
Vermont	yes	yes	0 to 100 feet

COUNTY	Buffer Requirement	Rating System	Buffer Range
Clark	yes	yes (I-V)	25 to 300 feet
Island	yes	yes (A-C)	25 to 100 feet
King	yes	yes (1-3)	25 to 100 feet
Pierce	yes	no	100 feet
Thurston	yes[2]	no	0 to 200 feet

CITY	Buffer Requirement	Rating System	Buffer Range
Anacortes	yes	no	25 feet min.
Bainbridge	yes	yes (I-IV)	25 to 150 feet
Bellevue	yes	yes (Class A-C)	0 to 50 feet
Bellingham	yes	yes (1-3)	25 to 100 feet
Bothell	yes	yes (1-3)	25 to 150 feet
Bonney Lake	yes	yes (I-IV)	25 to 200 feet
Burlington	yes	no	25 feet
Camas	yes	no	25 to 100 feet
Des Moines	yes	yes (Sig & Imp)	35 to 100 feet
Eatonville	yes	yes (I-IV)	10 to 100 feet

[1] State information includes proposed as well as adopted standards.

[2] Applied on a case-by-case basis

CITY Cont.	Buffer Requirement	Rating System	Buffer Range
Enumclaw	yes	yes (I-IV)	25 to 100 feet
Everett	yes	yes (1-3)	35 to 100 feet
Federal Way	yes	no	100 feet
Kirkland	yes	no	50 feet
Lacey	yes	yes (I-V)	25 to 300 feet
Lynden	yes	no	25 to 100 feet
Milton	yes	yes (I-IV)	25 to 300 feet
Olympia	yes	yes (I-IV)	25 to 300 feet
Port Angeles	yes	yes (I-IV)	25 to 300 feet
Puyallup	yes	yes (I-IV)	25 to 150 feet
Redmond	no	no	none
Seattle	yes	no	25 feet
Shelton	yes	yes	25 to 150 feet
Snoqualmie	yes	yes (1-3)	25 to 100 feet
Tacoma	yes	yes (I-IV)	25 to 200
Tukwila	yes	yes (1-3)	25 to 100 feet
Tumwater	yes	yes (I-IV)	25 to 300 feet
Wenatchee	yes	yes (I-IV)	50 to 250 feet

TABLE 2
Proposed Wetland Buffer Standards

COUNTY	Buffer Requirement	Rating System	Buffer Range
Clallam	yes	yes (I-IV)	25 to 200 feet
Grant	yes	yes (I-IV)	25 to 150 feet
Jefferson	yes	yes (I-IV)	25 to 300 feet
Kitsap	yes	yes (I-V)	25 to 150 feet
San Juan	yes	yes (I-IV)	35 to 200 feet
Thurston	yes	yes (I-IV)	25 to 300 feet
Whatcom	yes	yes (I-IV)	25 to 200 feet

CITY	Buffer Requirement	Rating System	Buffer Range
Auburn	yes	yes (I-IV)	25 to 300 feet
Blaine	yes	yes (I-III)	25 to 100 feet
Bothell	yes	yes (I-III)	50 to 200 feet
Edmonds	yes	yes (I-III)	50 to 150 feet
Everson	yes	yes (I-IV)	25 to 100 feet
Ferndale	yes	yes (I-IV)	25 to 150 feet
Fife	yes	yes (I-IV)	25 to 150 feet
Fircrest	yes	yes (I-IV)	25 to 200 feet
Gig Harbor	yes	yes (I-V)	15 to 150 feet
Hunts Point	yes	no	25 feet
Issaquah	yes	yes (I-IV)	25 to 100 feet
Kent	yes	No	50 to 150 feet
Longview	yes	yes (I-IV)	25 to 300 feet
Mill Creek	yes	yes (I-IV)	0 to 150 feet
Mt. Vernon	yes	no	25 feet
Nooksack	yes	yes (I-IV)	25 to 100 feet
Normandy Park	yes	yes (I-II)	35 to 100 feet
North Bend	yes	yes (I-III)	25 to 100 feet
Port Townsend	yes	yes (I-IV)	25 to 300 feet
Poulsbo	yes	yes (I-IV)	10 to 100 feet
Redmond	yes	yes (I-IV)	0 to 150 feet
Renton	yes	yes (I-III)	25 to 300 feet
Sedro-Woolley	yes	yes (I-III)	25 to 50 feet
Steilacoom	yes	yes (I-IV)	25 to 150 feet
Sumner	yes	yes (I-IV)	25 to 300 feet

IV. SUMMARY AND CONCLUSIONS

- Wetland buffers are essential for wetlands protection. No scientific study, no government agency, and no recommendations made during any communications with wetlands specialists nationwide suggested otherwise.

- Wetland buffers reduce the adverse impacts of adjacent land uses to wetlands. Wetland buffers also provide important habitat for wildlife which utilize wetlands and buffer areas for essential life needs. Buffers reduce wetland impacts by moderating impacts of stormwater runoff including stabilizing soil to prevent erosion; filtering suspended solids, nutrients, and harmful or toxic substances; and moderating water level fluctuations. They reduce the adverse impacts of human disturbance on wetland habitat including blocking noise and glare; reducing sedimentation and nutrient input; reducing direct human disturbance from dumped debris, cut vegetation, and trampling; and providing visual separation. They also provide essential habitat for wetland-associated species for use in feeding; roosting; breeding and rearing of young; and cover for safety, mobility and thermal protection.

- Buffer effectiveness increases with buffer width. As buffer width increases, the effectiveness of removing sediments, nutrients, bacteria, and other pollutants from surface water runoff increases. However, for incrementally greater sediment removal efficiency (e.g., from 90 to 95%), disproportionately larger buffer width increases are required (e.g., from 100 to 200 feet).

  As buffer width increases, direct human impacts, such as dumped debris, cut or burned vegetation, fill areas, and trampled vegetation, will decrease.

  As buffer width increases, the numbers and types of wetland-dependent and wetland-related wildlife that can depend on the wetland and buffer for essential life needs increases.

- Appropriate buffer widths are based on four variables: (1) existing wetland functions, values and sensitivity to disturbance; (2) buffer characteristics; (3) land use impacts; and (4) desired buffer functions.

- Wetlands with important functions and values or wetlands which are sensitive to disturbance will require greater buffers to reduce the risk of disturbance. Wetland functions, values, and sensitivity are attributes that will influence the necessary level of protection for a wetland. Those systems which are extremely sensitive or have important functions will require larger buffers to protect them from disturbances, which may be of lesser threat to a different site. Where wetland systems are rare or irreplaceable (e.g., high quality estuarine wetlands, mature swamps, and bogs) larger buffer widths will ensure a lower risk of disturbance.

- The uplands immediately adjacent to the wetland vary in their ability to reduce adverse effects of development, most importantly in relationship to slope and vegetative cover. Buffers with dense vegetative cover on slopes less than 15% are most effective for water quality functions. Dense shrub or forested vegetation with steep slopes provide the greatest protection from direct human disturbance. Appropriate vegetation for wildlife habitat depends on wildlife species present in the wetland and buffer. Effectiveness is also influenced by ownership of the buffer.

- Land uses associated with significant construction and post-construction impacts need greater buffers. Construction impacts include erosion and sedimentation, debris disposal, vegetation removal and noise. Post-construction impacts are variable depending on the land use, but residential land use, in particular, can have significant impacts. Residential land use is associated with yard maintenance debris, domestic animal predation, removal of vegetation and trampling. Wetland areas and their buffers should not be included in residential lots.

- Appropriate buffer widths vary according to the desired buffer function(s). Temperature moderation, for example, will require smaller buffer widths than some wildlife habitat or water quality functions. Buffer widths for wildlife may be generalized, but specific habitat needs of wildlife species depend on individual habitat requirements.

- Buffers of less than 50 feet in width are generally ineffective in protecting wetlands. Buffers larger than 50 feet are necessary to protect wetlands from an influx of sediment and nutrients, to protect wetlands from direct human disturbance, to protect sensitive wildlife species from adverse impacts, and to protect wetlands from the adverse effects of changes in quantity of water entering the wetland.

- In western Washington, wetlands with important wildlife functions should have 200 to 300-foot buffers based on land use. In eastern Washington, wetlands with important wildlife functions should have 100 to 200-foot buffers based on land use. To retain wetland-dependent wildlife in important wildlife areas, buffers need to retain plant structure for a minimum of 200 to 300 feet beyond the wetland. This is especially the case where open water is a component of the wetland or where the wetland has heavy use by migratory birds or provides feeding for heron. The size needed would depend upon disturbance from adjacent land use and resources involved. Priority species may need even larger buffers to prevent their loss due to disturbance or isolation of subpopulations.

- Buffer widths effective in preventing significant water quality impacts to wetlands are generally 100 feet or greater. Sensitive wetland systems will require greater distances and degraded systems with low habitat value will require less.
  The literature indicates effective buffer widths for water quality range from 12 to 860 feet depending on the type of disturbance (e.g., feedlot, silviculture) and the measure of effectiveness utilized by the author. For those studies which measured effectiveness according to removal efficiency, findings ranged from 50 to 92% removal of specific pollutants in ranges of 62 to 288 feet. Studies which measured effectiveness according to environmental indicators, such as levels of benthic invertebrates and salmonid egg development in the receiving water, generally found that 98-foot buffers adjacent to streams were effective. These latter buffer distances may be conservative for wetlands where lower water velocities and presence of vegetation result in increased sediment deposition and accumulation.

- Buffers from 50 to 150 feet are necessary to protect a wetland from direct human disturbance in the form of human encroachment (e.g., trampling, debris). The appropriate width to prevent direct human disturbance depends on the type of vegetation, the slope, and the adjacent land use. Some wetlands are more sensitive to direct disturbance than others.

- Some state agencies and many local governments rely upon wetlands rating systems to establish buffer widths. These rating systems are typically based upon perceived wetland value and upon acceptable levels of risk to the wetland from adjacent land uses. Of 16 states surveyed, ten require wetland buffers and eight incorporate wetlands rating, either adopted or proposed. Of five Washington counties, with adopted wetlands protection ordinances, all five require buffers and four utilize wetlands rating systems (the fifth is currently proposing an amendment which incorporates rating). Of 28 identified cities with wetlands protection ordinances (or interim ordinances), 27 contain specific buffer standards and 20 utilize wetlands rating systems. The city without specific standards has adopted an interim policy statement.

- Specific buffer requirements vary widely at the state and local level. This has resulted in differing buffer requirements and levels of wetland protection that are not necessarily effective. For example, the buffer requirements of many agencies are less than those that are reported in the literature to be effective.

  State buffer requirements range from 0 to 300 feet; Washington county buffer requirements range from 0 to 200 feet; and Washington city buffer requirements range from 0 to 300 feet.

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WETLAND BUFFERS - A FIELD EVALUATION OF BUFFER EFFECTIVENESS IN PUGET SOUND

Prepared for:

Washington Department of Ecology
Shorelands and Coastal Zone Management Program
Olympia, Washington

Prepared by:

Sarah Spear Cooke
Pentec Environmental, Inc.
120 W. Dayton, Suite A7
Edmonds, Washington 98020

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EXECUTIVE SUMMARY

Post-project assessments were carried out on twenty-one sites in King and Snohomish counties to analyze the effectiveness of required buffer widths and to identify factors which influence effectiveness. A protocol was first developed for examining buffer functions and effectiveness and selecting the buffer sites to be examined. The status of the buffers were examined in terms of their ecological functions and effectiveness.

Evaluating the effectiveness of buffers in protecting an adjacent wetland depends on the type of buffer in place, the type and size of the wetland it is protecting, the type of alteration to the buffer (type and concentration of disturbance to the surrounding areas), the width of the buffer, the time elapsed since the change in land use, and the ownership of the buffer and adjacent wetland.

Buffers were altered over time; more than 90% of the buffers examined for this study did not remain in a pristine state after the surrounding land use change was initiated. Of those buffers altered, 76% were altered in a negative manner.

Buffer functions were found to be most reduced as a result of decreased size of the buffer over time. Buffers less than 50 feet in width showed a 95% increase in alteration of the buffer. Where the buffer was greater than 50 feet, only 35% showed alteration. Overall, large buffers reduced the degree of changes to the water quality, the sediment load and the water quantity entering the adjacent wetland, especially over time.

As a rule, buffers are subjected to a reduction in size over time. Of the 21 sites examined, 18 were shown to have reduced buffer zones between one and eight years later.

I. INTRODUCTION

Background

Wetlands are sensitive to environmental changes that originate outside the wetland boundary. The degree of wetland sensitivity to these outside influences is dependent on a variety of factors including the type of wetland being impacted, the type of disturbance influencing the wetland, and perhaps the most important factor, the amount of non-wet buffered area between the wetland and the source of the disturbance. This study was requested by the Washington State Department of Ecology (Ecology) to provide an evaluation of the effectiveness of wetland buffers in reducing impacts to wetland habitats.

Purpose

The purpose of this study was to provide post-project assessments of required wetland buffers. The assessments provide a means to analyze the effectiveness of required buffer widths and to identify factors which influence the effectiveness of the buffer in protecting the wetland from impacts due to human-induced disturbances. Specific objectives of the buffer effectiveness study were:

- to assess effectiveness of buffers in protecting the integrity of wetlands;
- to assess the appropriateness of requiring variable buffer widths based on wetland vegetation community types and Ecology's four-tier rating system; and
- to determine qualitatively or quantitatively which ecological characters of the wetland and adjacent buffer area appear to significantly affect and/or protect wetland integrity.

To accomplish these objectives the following tasks were completed for each wetland site visited:

- a determination of whether the recommended buffer size and type was implemented;
- an evaluation of the type and extent of impacts to the buffer over time;
- an evaluation of the type and extent of impacts to the wetland over time as they were affected by the presence or lack of the buffer;
- identification of the important components of buffer functioning;
- identification of additional questions to assess effectiveness of buffers; and
- recommendation of priorities to use when designing or maintaining buffer characteristics based on interrelationships observed in the field.

II. METHODOLOGY

The following methodology was used for data collection and analysis for the buffer study:

Agency contact and Permit Identification

Local agency staff were contacted to assist in identification of appropriate sites. Agency staff provided a list of potential sites identified by permit applications. In addition, a large source of appropriate buffer sites was obtained from the study assessing the effectiveness of Native Growth Protection Easements performed by King County (Baker and Haemmerly, 1990). Agency and staff contacts are listed in Attachment 1.

Permit File Review and Site Selection

King County files for short plats, formal subdivisions, commercial permits, and wetlands were reviewed along with the State Environmental Policy Act files from the City of Kirkland and the 404 permit files from the Army Corps of Engineers. Information from Snohomish County files examined during the course of a previous study was used as well. Over eight years of permit files were reviewed.

Potential sites were identified based on the following criteria:

- presence of permit requirements for buffers;
- availability and thoroughness of pre-existing site data;
- age of project;
- availability of photographic record for the site (optional);
- location and accessibility of project; and
- agency staff or field personnel knowledge of the site.

Field Data Sheet Development

Data needs for the site specific assessment were identified and individual field data sheets were developed for buffer sites. These are located in Attachment 2.

The buffer data sheets were designed to collect consistent information on each site regarding pre-existing site conditions, permit requirements, design goals and objectives, existing site conditions, and qualitative assessments of success and function of the buffer. Data sheets were structured to collect both permit file and field data in the following general categories of information:

Pre-existing site conditions
Pre-existing conditions present before changes to the buffer area included: plant species diversity; dominant species; community type; pre-existing wetland type and size; surrounding land use; and functioning of wetland. Pre-existing conditions information was obtained from review of the files and/or from personal knowledge of the site by field personnel.

Permit requirements and buffer goals
Permit requirements and goals information was obtained from review of files.

Construction/implementation of permit requirements
Details of the surrounding use changes and buffer enhancement details (if required) were obtained from review of the permit files. Implementation of permit requirements were assessed both from review of the permit files and from on-site analysis.

Existing buffer and wetland conditions
Site conditions recorded for both the buffer zone and the existing wetlands included: plant species diversity; dominant species; viability of species; community type; buffer type and size; wetland type and size; surrounding land use; water quality assessments for sedimentation, turbidity, and chemical inputs; wildlife presence; and potential wildlife habitat available. This information was assessed on-site.

Buffer functions
Information gathered regarding functions of the buffer included: achievement of stated goals; evidence of wildlife use of the area; vigor and/or stability of planted vegetation species; habitat diversity; and impacts to the pre-existing wetland from various identified sources. This information was gathered on-site.

Summary Assessment
The assessment included the identification of probable factors affecting buffer functioning and a general analysis of the wetland/buffer system. Summary information was gathered on-site and was based on site conditions and investigators' knowledge of Pacific Northwest wetlands.

Field Site Establishment and Assessment

Potential sites identified during permit review were field-checked. Actual sites selected for analysis were a subset of the field-checked sites. Selection of actual sites was based on the following criteria:

- construction and implementation of the permitted project and buffer requirements;
- ability to locate the site;
- ability to access the site; and
- availability of pre-existing buffer and wetland conditions information.

Once a site was determined to be appropriate for inclusion in the study, the field assessment was conducted using the field data forms. Sites were assessed by transversing the area to define and characterize the buffer, and examine the wetland to determine if there were any impacts to the wetland as a result of the surrounding land use. A detailed description of the methodology which explains the basis for the field data form questions is provided in Attachment 3.

Data Analysis

Information collected in the field was reviewed and some simple statistical calculations were made regarding the different aspects of the data recorded on the forms.

III. RESULTS

Site Selection Results

A total of 35 potential buffer sites in King and Snohomish Counties were identified from agency permit files, Puget Sound Wetlands and Stormwater Management Research sites (Cooke et al. 1989a, 1989b), and from projects identified by agency personnel. Varying amounts of pre-existing data were available for the sites. Sites were excluded from the analysis for a variety of reasons. Many sites were excluded because they either could not be located or access was restricted, or they were implemented within the last year and it was not yet possible to evaluate the effects of development on the buffer and wetland. A few sites were eliminated because there was not enough pre-development data available to make a proper assessment of the post-development effects.

Of the 35 identified potential sites, 21 sites were selected as final data collection sites. Approximate locations are shown in Figure 1 and locations and details of these final sites are listed in Table 1.

The 21 sites include projects in:

- urban areas, commercial or public areas, and rural areas;
- areas with various degrees of disturbance to the area adjacent to the wetland. A 200-foot area adjacent to the wetland was set as the area to be assessed (based on the fact that 200 feet is the maximum buffer required by any of the implemented projects);
- areas with varied types of disturbance to the buffer and wetland including physical damage, deposition of garbage, introduction of chemical toxicants, and introduction of invasive species; and
- areas with the size and configuration of the protected wetland varying from less than one acre to tens-of-acres.

All 21 sites were located in areas where the degree of surrounding basin development was greater than 30%. Four sites were located in more rural areas, where the degree of surrounding development was 50% or less. Nineteen sites were in King County and two sites were in Snohomish County. Four sites were at least partially adjacent to agricultural lands, while eight sites had at least 25% second-growth native vegetation.

FIGURE 1 Locations of Buffer Sites in King and Snohomish Counties.

TABLE 1. Buffer Study Site Locations. (Sites are arranged by County from North to South.)

Site #	SITE LOCATION	COUNTY	S T R	BASIN	BUFFER IMPLEMENTED
1	4th Ave W and 220-224th St SW	Snohomish	/27N/4E	Lake Ballinger	1989-90
2	127 st SW and 155th Ave N	Snohomish	/28/4E	Lake Serene	1987
3	108-112 Ave NE and NE 155-158 St.	King	17/26N/5E	Juanita Creek	1989
4	Inglewood Rd and NE 165th St.	King	11/26N/4E	East Lake Wash	1989
5	134-135 Ave NE, and NE 187-190 St	King	3/26N/5E	Bear Creek	1986
6	189-196 Ave NE and Snohomish City line and NE 202 St.	King	6/26N/6E	Bear Creek	1987
7	NE Novelty Hill Rd and 212 E and 220th Ave NE	King	33/26N/6E	Bear-Evans Creek	1988
8	NE 133 and NE 145th and 214-228 Ave NE	King	21/26N/6E	Bear Evans	1987
9	224 Ave NE and Union Hill Rd	King	9/25N/6E	Evans Creek	1987
10	221st St and 225 Ave NE and NE 16-20th	King	28/25N/6E	Evans Creek	1987
11	NE 16 and NE 18th Pl, and 225-226 Ave NE	King	28/25N/6E	Evans Creek	1987
12	E 212 Ave SE and SE 32nd St.	King	9/24N/6E	E.Lk. Sammamish	1983
13	Issaquah Pine Lk Rd.	King	33'22N'6E	E.Lk. Sammamish	1988?
14	E. Lk. Samm. Prkwy SE and SE 40th and 204 Ave SE	King	17/24N/6E	E.Lk. Sammamish	1986
15	SE Duthie Hill Rd and 260-268 Ave SE and SE 32 St.	King	12/24N/6E	Patterson Creek	1985
16	E SR 203 and NE 24-28th St.	King	21/25N/7E	Snoqualmie River	1983
17	Kent Kangley Rd. and Witte Rd.	King	33/22/6	Jenkins Creek	1988
18	SW Auburn Black Diamond Rd and SE 324 St	King	13/21N/5E	Soos Creek	1986
19	SE Auburn Black Diamond Rd and SE 325th Pl.	King	18/21N/6E	Soos Creek	1987
20	124-128 Ave SE and SE 78-89th	King	28,33/24N/5E	May Creek	1987
21	116 Ave SE and SE 76 St.	King	28/24N/5E	May Creek	1987

Buffers were, without exception, heterogeneous in nature, consisting of a mosaic of different types: paved surfaces; native forest and shrubs; invasive shrubs; mowed lawns; and fences. Buffer widths varied from 0 to greater than 200 feet. All but one of the buffer zones were not uniform in width. Of the 21 sites, four had buffers that were at least partially enhanced. Enhancement consisted of planting other species to increase the density of the existing vegetation, replacement of the pre-existing community, or widening the pre-existing buffer width. The ages of the post-development buffers ranged from two to eight years (1983 to 1989).

The types of disturbances affecting the buffers and adjacent wetlands included grading; filling; removal of vegetation; dumping of yard waste and garbage; inputs of fertilizer, sediment, and toxic substances; and noise pollution from adjacent roads and houses.

Buffer site characteristics are summarized in Table 2.

TABLE 2. Buffer Site Characteristics.

Site #	Buffer width (feet)		Wetland Type*1	Buffer Type*2	Age of Buffer	Surrounding Use	Disturbance Type*3
1	variable	0-200+	1	pv,shi,shn fn, f	1	residential, native veg	p,ct,cf,s
2	variable	0-20	2	f,gr,fn,shn	2-4	residential,native veg	ct,cn,p,s
3	variable	10-100	3	pv,shi	3	residential,native veg	p,ct,s
4	variable	0-10	2	pv,f,shi	4	agric, native veg, residential	p,ct,cf,s,
5	variable	0-50	2	pv,shi,fn	8	native veg,residential	p,ct,cf,s
6	variable	15-50+	3	f,pv,shn	4	residential, native veg	ct,p
7	variable	15-100+	2	gr,f,fn,pv	3	residential	p,ct,cf,s
8	variable	50-200	2	f,shi,shn,gr	4	residential, native veg	ct,p,cf,s
9	variable	0-100	2	gr,f,shi,fn	4	residential, native veg	ct,cf,p,s

TABLE 2. Buffer Site Characteristics. (cont.......)

Site #	Buffer width (feet)		Wetland Type*1	Buffer Type*2	Age of Buffer	Surrounding Use	Disturbance Type*3
10	variable	0-50	2	f,gr,fn	4	residential	ct,p,s
11	variable	15-50	2	shn,shi,pv	4	residential, native veg	ct,p,cf,s
12	variable	0-50	1	gr,f,pv,shn	8	residential, native veg	p,cf,s
13	variable	0-35	2	pv,gr, shi	5	residential, native veg	p,cf,ct
14	variable	0-25	2	gr,shi,pv	5	residential, agric	p,ct,cf,s,n
15	variable	0-50	2	pv,f,gr,shn	6	residential, native veg	ct,cf,p,
16	variable	0-130	2	f,shn,gr	8	residential, native veg	cf,p,s,n,
17	variable	0-150	2	f,shi,shn,gr	3	residential,agric,	p,ct,cf,s,
18	variable	0-35	2-3	fn,shi,gr,pv	4	residential, native veg	p,ct,cf
19	variable	25-200	2	f,shn,pv	4	residential,road,creek native veg	p, cf,n,
20	variable	0-25	3	pv,fn,gr	3	residential, native veg	p,ct,cf,s
21	variable	0-150	2	shn,gr	4	residential,native veg pasture	p,cf,s

***1 WDOE wetland category**
Category 1
Category 2
Category 3
Category 4

***2 Buffer type**
pv=pavement
gr=grass,maintained
shi=shrubs,invasive
shn=shrubs natural

***3 Disturbance type**
p= physical disturbance
cf= chemical input fertilizer
ct= chemical input toxics
s= sediments
f=forest,native
fn=fence

Field Data Site Summaries

Site information recorded on the field data forms is summarized in Attachment 5. Summaries include the following baseline information: pre-existing conditions for both the buffer and wetland, permit plan requirements and existing buffer and wetland conditions and approximate acreage if available. In addition, each site summary addresses if the wetland buffer width and type implemented as required from the easement and general provisions; what the current condition of the buffer and adjacent wetland are, and if the buffer appears to be functioning; what the critical components affecting functioning of the buffer appear to be; if the buffer goals established by the permit were met, and if they were realistic in terms of providing for all the potential disturbances that could affect the wetland.

IV. DISCUSSION

The primary objective of the field component was to assess the effectiveness of currently existing buffer zones around wetlands in protecting the wetland from disturbance (of any kind). The investigation was further expanded to include an assessment of the important factors contributing to the success of the buffer zones; identification of the sources of disturbance to wetlands; and an analysis of the apparent response of different categories of wetlands to the disturbances and the efficiency of different buffer types in protecting the different types of wetlands.

It was necessary to define, or at least list criteria of "effectiveness." Ecological function can occur on many different levels, and perception of effectiveness may vary considerably from one scale to another. For example, one function of a buffer may be prevention of human physical intrusion into a site. A fence may be unattractive, and may allow stormwater drainage to pass through, but if it is functioning as a physical barrier, it is at least effective on that level.

The data collected was analyzed mostly in a qualitative manner. A series of questions were developed to determine pre-existing conditions (buffer and wetland), buffer goals, current conditions (buffer and wetland), and whether the goals were achieved.

A result of this analysis was identification of factors affecting the function of buffers and a qualitative hierarchial ranking of the factors affecting buffer function and their importance in terms of wetland protection.

The following section also discusses the appropriateness of existing buffer requirements in terms of different perspectives of value (e.g., wildlife habitat, aesthetics, ecological functioning etc), based on the results of this study.

<u>Buffers, Ecological Requirements and Constraints</u>

Wetland buffers are physical barriers between a wetland and an external source of disturbance that act to screen the wetland from that disturbance. "Disturbances" can take the form of physical disruption (e.g., mowing, digging), chemical disruption (e.g., inputs of toxicants, fertilizers), competitive disruption (e.g., introduction of invasive species), noise disruption (e.g., road noise), and visible disruption (e.g., removing the tree and shrub canopy that provides screening).

An assessment of potential functions and values of buffers is similar to a list of habitat functions in general. They include but are not restricted to wildlife habitat, water quality enhancement through stormwater filtering, flood storage, groundwater recharge and discharge, seed banking, and aesthetics.

Establishing ecological goals for wetland buffers should include an assessment of the historic, current, and future disturbances to the wetland, and an evaluation of necessary buffer requirements to prevent these disturbances from impacting the wetland. As with any natural system, it is impossible to identify all the ecological factors that could be effected. At the very least, the major factors should be considered, and goals for desired wetland functions and buffer requirements to maintain these functions should be established.

Establishing buffer widths may be done as a risk assessment procedure. The more sensitive the wetland, the greater the risk that the system will be affected by a given disturbance. If the wetland if of little value (usually based on biological functions, but not restricted to that), and the land is valuable, than it may be worth the risk to allow a narrow buffer, because there is not so much to lose if the buffer doesn't function to stop the disturbance to the wetland. On the other hand, if the wetland is a rare system such as bog, or a mature forested wetland, it may not be worth the risk that a narrow buffer will not serve its functions, because the wetland is irreplaceable.

Another important consideration is the concept of "buffer averaging". Buffers are very seldom of uniform consistency or width. A common upland/transition zone of a natural systems may be a combination of pasture on one edge, forest on another, and shrub on the remaining edge. Each of these areas functions on its own as well as in conjunction with the other areas. Buffer averaging allows variable buffer widths around wetlands. Often, little consideration is given to the different character of the vegetation communities in the buffer. A grass lawn or a cement parking lot do not offer the same functions or values to buffering the wetland as a forested patch. A single entrance point is all it takes for physical disturbance or stormwater inputs to effect the entire wetland. It is, therefore, important to consider the "weakest link" in buffer averaging. The smallest buffer, or the buffer which affords the least protection, should still be capable of maintaining the integrity of the buffer to prevent disturbance to the wetland. Because buffers are often constrained by the physical lay of the land, buffer averaging may be reasonable in some instances without impacting the wetland. An example is where the wetland is located along the toe of a very steep slope. There may only be a few feet available for a buffer.

Wetlands and their surrounding buffers function together; the processes occurring within them are interrelated, and disturbance to any one component of the ecosystem by necessity will effect the rest. Removal or change to the vegetation community in a portion of the buffer may have no effect to the wetland, but it may also show a compounded affect; a small disturbance may be magnified by the next interaction with the different buffer types and eventually be a large effect on the wetland itself. For example, if a small portion of the upland forest is removed, this may afford physical access by humans and domesticated pets to the buffer that remains, and subsequently, to the wetland edge itself.

Buffer Site Functions

Some functions and values associated with buffer zones and identified for the purposes of this study include stormwater attenuation, water quality improvement, groundwater recharge, discharge, barriers to physical disturbance, and barriers to noise disturbance. Each of these functions is discussed with respect to findings in the 21 study sites.

Stormwater attenuation
Buffer sites that are adjacent to developments are intended to prevent or reduce stormwater entrance into the adjacent wetland. The degree to which the buffer succeeds in this function is related to the topography of the site, to the vegetation in the buffer, and to the effectiveness of modifications made to the buffer in order to enhance this function.

Buffers can act as enhanced catchments (i.e., retention/detention facilities [R/D]), and/or provide biofiltration for stormwater, and provide storage of stormwater. The use of the buffer areas for R/D has variable impacts on both the functions of the buffer, and on the adjacent wetland systems. Use of the buffer for a stormwater function such as R/D defeats the buffer purpose, because the area is no longer a barrier system, but is a holding system. Overflows from the R/D are closer to the wetland and have more of a chance of entering the wetland. One study site included a sphagnum bog. Here, the change in nutrient balance from incoming stormwater was adversely impacting the vegetation community within the bog because the water from the buffered area is directly entering directly the wetland. In contrast, a second site provided for R/D within a dredged pond, down slope from the mature forested system within the pre-existing wetland. The flood storage is designed to occur primarily within the pond in the buffer, and no direct adverse impacts were readily visible within the forested community. No attempt was made to assess pre-development and post-development conditions within this forested community to determine species or community impacts.

Water quality improvement
Water quality functions of the buffer can be provided by biofiltration of sediments within a vegetated system, by nutrient uptake within the vegetated system, and by providing a settling basin for the deposition of suspended solids. Most of the sites contained areas in their buffers that could perform at least a small part of this function. Inputs of stormwater do not always flow into areas where the vegetation and buffer width are sufficient to function as removal areas. Stormwater and surface water was observed to flow through buffer zones and into wetlands in six of the 21 (28%) sites. These sites demonstrated the greatest observable changes in the wetland edge vegetation.

Barrier to physical disturbance
Buffers can provide a barrier against physical disturbance of the wetland. Some buffers are more successful at this than others. For example, a 200-foot forested buffer is more effective than a 25-foot paved sidewalk. Fencing is perhaps the optimum physical barrier if the fence does not have a gate. Fences can also act as visual screens which may afford better protection for wildlife than shrubs or a lawn. Twelve of the 21 sites had fencing along the edge of the adjacent property, although most had gates which allowed entrance to the buffer and subsequently to the wetland. Sixteen of these sites showed evidence of disturbance in the form of disposal of yard waste, and physical deterioration of the vegetation due to trampling from the gate access point.

Barrier to noise disturbance
This function is especially important when the wetland is essential nesting or breeding habitat. This function was not a listed as a permit goal for any of the 21 sites examined, but it was a

function that was important for at least two of the sites that were adjacent to busy roads. A shrub barrier or forested zone would be more effective as a sound barrier than a grassy lawn.

Wildlife Habitat

Although assessment of wildlife use and habitat availability was limited to one observation from each site, a preliminary assessment could be made for these components of wetlands functions. Seventeen of the 21 sites listed enhancement of the buffer for wildlife habitat as a goal in the permit. Habitat components that can be provided by the buffer include vegetation species diversity, structural complexity, community complexity, and shelter. An important use of the buffer for wildlife habitat is to provide shelter and above-ground nesting sites for species that utilize both the wetland (often for feeding) and the upland areas. Buffers with low diversity benefitted greatly from diverse adjacent wetland habitats. Sixteen of the 21 sites contained sufficient species and/or community diversity to act as wildlife habitat. This includes buffers with forested and native upland scrub-shrub zones, as well as native or undisturbed grassy areas.

Sites which were either paved or mown grass offered little habitat for either food or shelter. Areas in buffer zones dominated by reed canary grass provide very little species diversity or habitat complexity. None of the buffers examined were of uniform type along the wetland boundary. This heterogeneous nature enhanced the species diversity component, especially where the buffers tended to be paved, or mown grass.

Although it was not always possible to determine, it appeared that many sites were enhanced by planting species in the buffer. This added structural diversity to the buffer community that was not present previous to the implementation of the change in the surrounding land use.

Aesthetics

A buffer function that is uniquely important to humans is the aesthetic quality of the buffer. This function includes values associated with open space and views, opportunities for passive recreation (e.g., bird watching, walking on paths), and opportunities for education. Human activities within buffers may include placement of interpretive walks, decks or other structures within the buffer, or wetland edge itself, and/or planting non-native ornamental species in the buffer rather than native species.

Only two sites out of the 21 (9%) included buffer enhancement for aesthetic purposes. These included planting of ornamental species for color, and attractive blooms, and development of interpretive walks, and trails and signs. Although incorporation of trails within buffers and wetlands provides the opportunity for human education and recreation, it also encourages intrusion into the wetland by humans and domesticated animals. Trails were found in the buffer zones of six of the 21 sites. Without exception, the trails disturbed the buffer vegetation and gave access to the wetland that resulted in visible deterioration of the wetland edge.

Components of "Success"

A series of questions were asked about the buffers at each site in order to determine if they were effective in protecting the adjacent wetland. The intention of this method of assessment was to establish baseline conditions; to determine if the buffer was established as it was required or designed; and to determine the condition of the buffer over time. Many of the sites were previously assessed in 1988 as a part of a buffer survival and effectiveness study performed by King County Building and Land Development (Baker and Haemmerly, 1990).

Where the information was available, pre-existing conditions were evaluated for all sites. The same detail of information was not available for all the sites.

Of the 21 sites assessed, 20 were implemented as outlined in the easement conditions, however, this was a very subjective assessment due to the lack of detailed description of buffer provisions.

Difficulty in assessing buffer functions made it difficult to respond to the question of whether the buffer was functioning. It was first necessary to assess whether the buffer was functioning as outlined in the buffer/easement requirements, and then to next assess what further functions were being performed by the buffer, and what other functions should be present in the buffer zone in order to protect the wetland from disturbance. Given the general and sometimes vague description of the easement goals, results of this study were often difficult to determine. This was compounded by the fact that most of the buffer zones were not "created," but remained from the pre-existing buffer.

All but one of the buffers examined (95%) showed some signs of alteration over time. This surprisingly high number indicates the need for including easement requirements which reflect not only current disturbances, but post-development disturbances as well. This level of impact also suggests a need for monitoring buffers and wetlands after development has occurred in order to identify disturbances before they have adverse impacts on wetlands. This exceeds the 68% alteration found in the BALD 1988 study.

Table 3 lists important components of buffer success that were studied for each site and explained in the following discussion.

<u>Degree of urbanization</u>
The degree of urbanization surrounding a wetland can have a direct correlation with the amounts and kinds of disturbances affecting the wetland. The more developed a basin associated with a wetland, the more potential deleterious inputs there are to the wetland. The Puget Sound Wetlands and Stormwater research Program is examining this trend in the wetlands around King and Snohomish Counties, and will have the results of the study ready in 1992.

Table 4 reviews the degree of adjacent urbanization as it compares to the amount of alteration has occurred in the wetland. Sites rated as "highly altered" display characteristics of the water, vegetation, wildlife and/or soils have visibly changed and deteriorated in the recent past. Sites rated as "moderately altered" show few degradations to the wetland/buffer, although they do not threaten the wetland. "Low alteration" indicates the buffer has been barely modified.

TABLE 3: Components of Buffer Success

Components of Buffer Success		
a.	Degree of urbanization	Low < 15% adjacent developed medium 15 to 45% adjacent developed high >45% adjacent developed
b.	Surrounding land use	Urban residential commercial public Rural agricultural forested, native growth
c.	Buffer Size and Characteristics	0-200+ feet of buffer width Variable widths for the total length Characteristics paved surface grass maintained lawn shrubs, invasive (blackberry) shrubs, native forested
d.	Time	elapsed since project implemented
e.	Implementation components	Buffer left in-tact Buffer planted, and/or enhanced
f.	Buffer Maintenance	Prevention of encroachment Education of nearby residents

TABLE 4 The Number of Altered Buffer Sites Versus the Degree of Adjacent Urbanization/Surrounding use

site #	level of urbanization %	surrounding use RS	RM	NV	S	altered?
1	75	X		X		highly
2	90	X		X		highly
3	60	X	X	X		moderate
4	50	X	X		X	highly
5	40		X	X		moderate
6	85	X				no
7	100	X				moderate
8	95	X		X		low
9	70	X		X		moderate
10	100	X			X	moderate
11	70	X		X		low
12	70	X		X		moderate
13	85	X		X		highly
14	100	X				highly
15	85	X		X		highly
16	65	X		X	X	highly
17	60	X	X			moderate
18	85	X		X		moderate
19	50	X		X	X	low
20	85	X		X		highly
21	35	X		X		highly

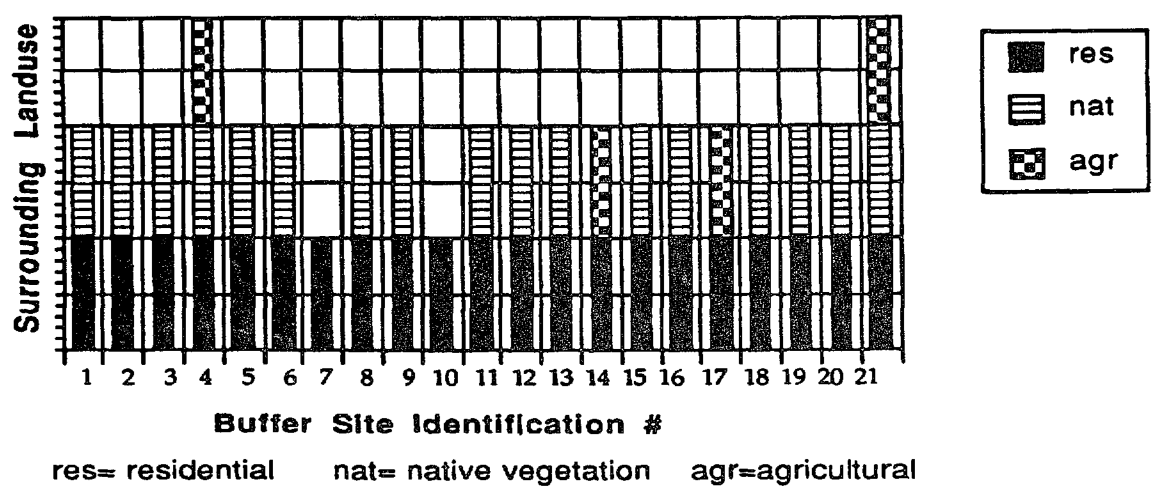
RS= residential single family
RM= residential multifamily
NV= native vegetation, usually forested or shrub growth
S= stream

Surrounding Use

Human use of the areas surrounding a wetland results in direct impact on the wetland from associated activities. Logging, and clearing of vegetation up-slope from a wetland can result in acidification of the surface waters, and release of copper, nutrients, and sediments into the overland flow. This type of adjacent activity was observed in ten of the sites studied. In five cases, the deposited sediment load was still present in low-lying depressions or in the meander channels of rivers and streams. Six of 11 sites (55%) adjacent to developments which use lawn maintenance systems showed apparent effects of the input of fertilizers on the wetland vegetation. This was observed as luxuriant growth near the inlet areas, invasion of the wetland edge by invasive species, and in one case, toxicity symptoms from over-fertilization by nitrogen.

Sites with greater than 60% surrounding area as residential showed varying degrees of disturbance to the buffers and/or wetland. There were 16 sites that showed the adjacent use to be 50% or greater development as single and multiple family residential. Figure 2 shows the breakdown of adjacent use by wetland.

FIGURE 2 Surrounding Land Use for Each Wetland/Buffer Site

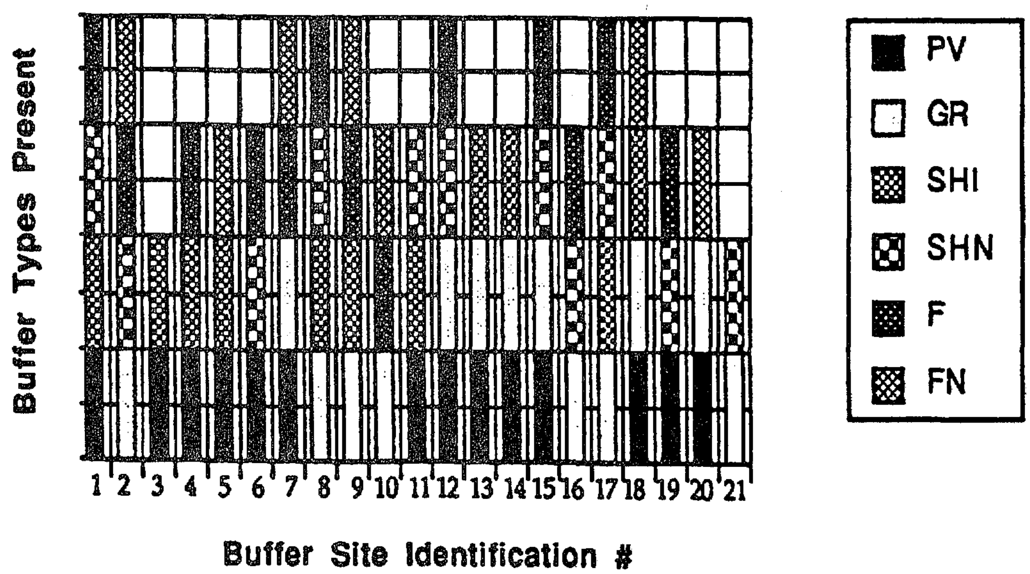


Buffer size and characteristics

Lack of appropriate vegetation densities and/or species diversity contributed to lower function as a community in 15 of the 21 sites. The density question is one not often addressed in vegetation community analysis, but it is important because insufficient densities result in "filling in" with weedy species such as red alder, black alder, black cottonwood, and Himalayan blackberry. Species diversity was lacking in 14 of the 21 (67%), buffer areas which were in-tact. The buffer consisted predominantly as a monoculture, usually Himalayan blackberry, or lawn grass. These communities offer very little wildlife habitat.

More diverse communities and higher densities of this diverse vegetation is the reason for the success of the buffer in the remaining six sites. The density component is especially important when the buffer width is small (less than 50 feet). A buffer of 25 feet worked in only one out of 25 (5%), where the vegetation was so dense the buffer formed a completely impenetrable barrier. None of the wetlands had a buffer that was uniform in width. The buffer widths ranged from 0 to greater than 200 feet across the length of a wetland edge. Qualitative observations were made in the field which indicated that the buffer areas that were 50 feet or greater showed less impacts to the wetland areas directly adjacent than those areas that were less than 50 feet in width. Nineteen wetlands (90%) had areas where the buffer was less than 25 feet and disturbance to the wetland edge would occur at that point.

Figure 3 Buffer Types Surrounding Each Wetland



PV=pavement GR=grass,maintained SHI=shrubs,invasive
SHN=shrubs natural F=forest,native FN=fence

Time
One of the criteria for site selection was sites that had been implemented for more than one year. The projects at the study sites ranged in age from two to eight years old.

Two components of age are important in the analysis of the buffer efficiency. The first is the age as it reflects the regulations that were in place at the time of implementation of the project. Projects dating after 1987 required that the buffers be placed outside of the lots. This requirement had one of the highest impacts to preservation of the buffers in an unaltered state. Projects that incorporated the buffer in the lots always resulted in the loss of the natural vegetation community to lawn over time (i.e., 17 out of 17 eligible sites). Ownership of the buffer appears to mean to the homeowner that it is acceptable to remove the natural vegetation and replace the buffer with a less valuable, mown-lawn type of buffer.

The second component of age is the time elapsed since implementation of the buffer. The number of alterations to the buffer increase with the time passed since the buffer was established. Figure 4 illustrates buffer age compared to the degree of alteration of the buffer. Table 5 lists the percentage of buffer alterations over time as indicated by both the 1988 (Baker and Haemmerly, 1990) and this study.

FIGURE 4 Buffer Age Compared to the Degree of Alteration of the Buffer

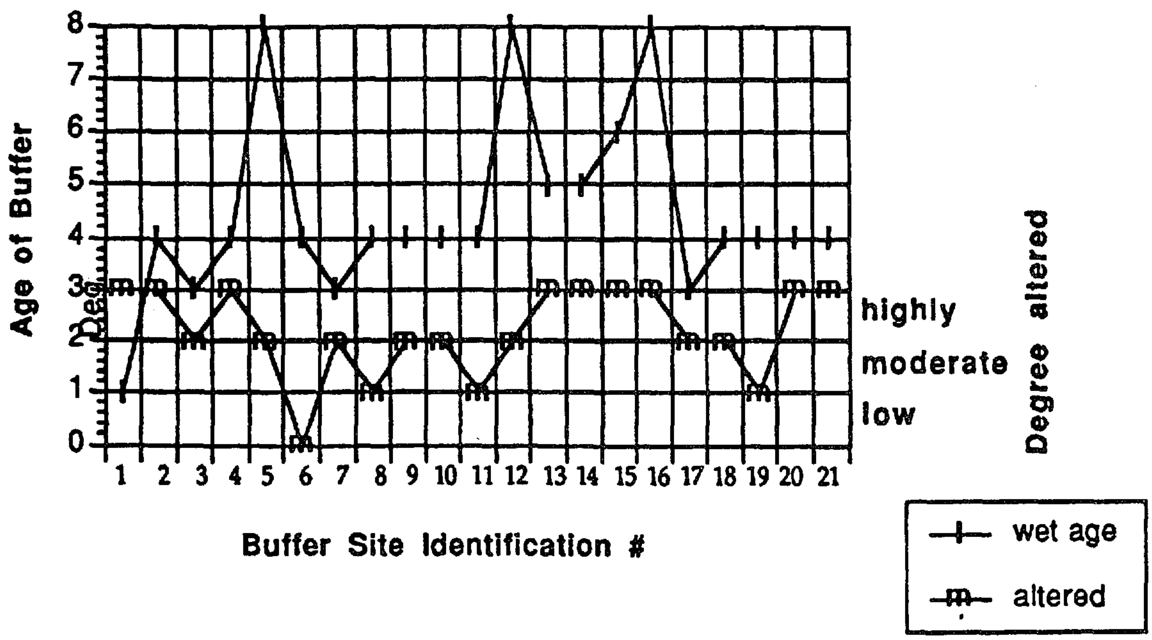


TABLE 5 Percentage of Buffer Alterations Over Time

year	% buffers altered 1991 study	% buffers altered 1988 study
1983-84	(2/2) 100%	2/2) 100%
1985-86	(4/4) 100%	(4/7) 57%
1987-88	(11/12) 92%	(7/10) 70%
1989-90	(3/3) 100%	--
average	(20/21 95%	(13/19) 68%

Implementation Components

In general, most of the buffers were, at least initially, implemented as required by the easement provisions. Unfortunately, buffers seldom require monitoring and buffer zones were altered with time in over three-quarters of the study sites. Important components of implementation include: whether the buffer was planted, or existed previous to the development or disturbance; if the buffer was enhanced or expanded; and the value of certain species or community types found in the buffer in terms of providing the habitat and functions needed for the buffer.

The higher the density of plants in the buffer the better the protection and the greater the functions. Densities were described as low (e.g., mown lawns, pavement), medium (e.g., open thinned forest with no undergrowth, planted shrub in low densities), and high (e.g., fallow native grasslands [unmown], dense forests with undergrowth, solid shrub layer, either invasive species [blackberry species] or native species [Snowberry, salmonberry, or vine maple]). Lack of appropriate vegetation densities contributed to lower potential for buffering of the buffer zone. Although the determination is subjective, densities as a whole were too low in all the study sites. Buffers appeared to decrease in density over time (where it was possible to determine).

Maintenance Components

There was no instance of a monitoring requirement for the buffers of the 21 sites examined. This lack of maintenance following the implementation (be it leaving the existing community alone, or enhancement of the buffer) is associated with alterations to the buffer over time in 20 out of 21 sites.

V. FIELD STUDY CONCLUSIONS

The primary purpose of this study was to assess the efficacy of buffers in protecting an adjacent wetland. In addition, it was necessary to determine what types of functions buffers offer, and to determine whether these were being met at the study sites.

During the course of the study, it became clear that the goal statements and easement provisions were so general and unspecific that only outright removal of the buffer and severe disturbance to the adjacent wetland could be interpreted as a failure of the buffer to meet the goals. Goal statements, when they existed, were generally written to address a single function of the wetland to the exclusion of all the other important functions that occur. Incomplete understanding of the types of disturbance that may occur to the wetland and buffer as a result of the implementation of a land-use change in the surrounding area is a large factor in the failure of buffer requirements to sufficiently protect the wetland. In addition, none of the easement provisions required monitoring, or provided for post-development analysis of success of the buffer to function fully. By not addressing components of the wetland that can be measured, (vegetation species numbers, densities, and diversity), there is no method of determining if the goals or provisions have been met. As a rule, buffers were most affected by a reduction in size over time. Buffers are being altered, both in the short term, and definitely in the long term. In no sites with 25-foot buffers were the buffers functioning to reduce disturbance to the adjacent wetland, either in the short term or long term. In addition, buffers, regardless of size, appear to be continuously reduced over time. There is argument therefore to provide for the largest buffer possible so that when some of the buffer is lost over time, there is still sufficient buffer to protect the wetland.

The critical components of successful buffer function depend on the type of buffer in place, the type of alteration to the buffer (and type of disturbance to the surrounding areas), the width of the buffer, the surrounding land use, the time elapsed since the change in land use, and the ownership of the buffer and adjacent wetland. Buffer efficiency at protecting the adjacent wetlands is dependent on the following components:

- <u>the number of lots adjacent to the buffer</u> - the fewer the lots the less the impacts;
- <u>the size of the buffer</u> - the larger the buffer the more protected the wetland;
- <u>the type of buffer in place</u> - vegetation communities which act as; visual screens, physical barriers, sediment filters and chemical filters efficient buffers; and
- <u>ownership of the buffer</u> - buffers owned by landowners that understand the purpose of the buffer are less impacted.

Buffer functions were found to be most reduced as a result of decreased size of the buffer. Buffers less than 50 feet wide showed a 90% increase in alteration of the buffer (19 out of 21), while only 43% (3 out of 7) showed alteration in those buffers where the buffer was greater than 50 feet. Overall, larger buffers reduced the degree of changes to the water quality, the sediment load and the water quantity entering the adjacent wetland.

The findings of this study of a small subset of sites within the central Puget Sound region suggests that on the whole, buffers are not being regulated or enforced in a way that provides for their maximum ability to function. Goals established in easement provisions are inadequate to prevent the alteration of buffers over time, and consequently, are also inadequate to prevent alteration to the adjacent wetland. The study illustrates the shortcomings of the regulatory aspect of wetlands protection from both a biological and a best management policies perspective.

However, an increased understanding of the ecology of wetlands and buffers, the incorporation of as many site variables as possible, and the mandatory monitoring of characteristics that can indicate quantitative changes will result in an increased likelihood of the success of buffer zones to protect adjacent wetlands from disturbance.

VI. STUDY LIMITATIONS

This study has provided us with some valuable insights into the functions of buffers and their ability to protect wetland. However, inherent in this study and its results are several limitations.

No attempt was made during this field study to review all available files or to identify all possible sites; a small number of sites within a limited field radius was chosen for analysis. As a result, the conclusions which can be drawn from this study are limited. Sizes, types and conditions of the sites assessed in this study are a small sub-set of available within the Puget Sound Basin. It is the opinion of the field investigators that the sites visited may actually represent a relatively realistic sample of "typical" sites within this region. It was outside the scope of this study to field check sites located in the major portion of the state of Washington.

Further, sites were visited only once during this study; evaluations of site functions over time are speculative, and are based on site conditions during the visit and investigator expertise. Sites were assessed during March, when many plant species are still dormant or just beginning to break dormancy. As a result, ability to assess health of the system, as well as viability and robustness of some species was limited. Assessment of the functions of various plant groups within the entire wetland was limited and may have been different if the site were visited later in the year. For example, shrub functioning may have been underestimated in some wetlands because the shrubs were not leafed out. Similarly, the ability to assess the effectiveness or appropriateness of planting densities may also have been limited by the time of year.

Finally, most study sites consisted for the most part of younger sites (not greater than 8 years of age). This limited the ability to look at site development and functions over time. This age limitation is a reflection of the relative young "science" presented as wetland ecology. It is the opinion of the investigators that many of the sites observed and assessed will be providing more complex functional value over time.

VII. RECOMMENDATIONS

The following recommendations are based on the findings and results of this field study and on the professional experience of the authors. Although this component was limited to a field assessment and not a literature search and analysis of the state of buffers, the authors are aware of other field studies which corroborate the findings, conclusions, and recommendations of this study. Citations of those studies are included within the references for this report.

These recommendations are formulated based on several consistent findings: first, that a pre-existing conditions assessment is rarely conducted, and, if conducted, is incomplete; and second, that buffer goals/easement provisions must be based on quantifiable characteristics that allow for an accurate determination of subsequent alterations to the functions of both the buffer and the wetland.

Pre-existing Conditions Assessment

This assessment must be conducted for the wetland communities present before the surrounding land use change comes into affect. A through analysis of the vegetation (at the very least), functions of the existing wetland and buffer, and wildlife (if time and budgets are available) should be accomplished. This provides a reference for future monitoring comparisons.

The assessment must be conducted in a manner that collects quantifiable data on existing wetland characteristics. Protocols for similar monitoring of water quality and quantity, vegetation, soils, and wildlife can be found in Horner (1989, 1990), Cooke et al. (1989a, 1989b), and King County (1988). Monitoring protocols are currently being developed by the Puget Sound Wetlands and Stormwater Management Research Program and should be available in a draft form in 1992.

Establishing Buffer Goals and Objectives

The goals and objectives of the buffer must be established in such a manner that success or failure of the buffer to protect the wetland can be determined. Future disturbances to the wetland and buffer must be defined in order to incorporate all the functions that the buffer will be required to perform to prevent impacts to the buffer or wetland. These goals must be defined in detail, taking both ecological and aesthetic functions in consideration, and the assessment protocol must be established before the project is implemented. Buffer requirements must be established so that any required enhancements are written into the easement provisions.

Implementation

A wetlands ecologist should be involved in the design and implementation of the project in order to ensure the required provisions are implemented. Existing functional natural communities should be used as a model for the buffer if it is determined that the existing buffer will not be able to function sufficiently to protect the adjacent wetland from the projected disturbances.

Monitoring/Enforcement

Monitoring of buffers and adjacent wetlands over time is necessary to ensure maintenance of their characters and functions. A monitoring program should be established for the buffer and wetland which incorporates the quantifiable components of the baseline/pre-existing conditions. Changes in the characteristics, especially vegetation community (e.g., species composition, percent cover, species density) can be discovered before the alterations become so great that the wetland is at risk. A timeline should be written into the easement provisions so that monitoring requirements can be bonded. There should be some means to ensure the requirements are being met, and that the buffer requirements are maintained over time.

Maintenance

Alterations to the buffer should be immediately remediated. Maintenance of the buffer for the function goals established should be included in the easement requirements along with the monitoring program. Maintenance may include control of non-native invasive species, replanting of species removed, and enhancement of buffer vegetation to improve certain functions that are not being met.

To summarize, it is important to look at each new project and define a plan for the implementation of the project to avoid impacts to the wetland. This can best be accomplished by first, determining the potential sources of impact to the wetland given the surrounding current and projected future land use, in conjunction with the type of wetland to be influenced; and second, establishing goals wetland functions that consider these sources of potential disturbance, and by requiring buffers of sufficient size (minimum of 50 feet, regardless of the type of buffer) and type that can fulfill these goals, over time. It is also necessary to establish a quantified assessment of the pre-existing wetland and buffer communities in order to establish if the buffers are functioning to protect the wetland from impacts due to land use changes over time.

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Attachment 1 - AGENCY AND STAFF CONTACTS

The following agencies and staff were contacted to identify potential sites

KING COUNTY, Building and Land Development
Technical Services Section
Tina Miller, Heather Stout, Laura Kaye
Subdivision Products Section
Howard Haemmerly

CITY OF KIRKLAND,
Joan Brill

CITY OF BELLEVUE,
Toni Craemer

ARMY CORPS OF ENGINEERS,
Michelle Walker

Attachment 2 - **BUFFER SITE FIELD DATA FORMS**

Investigator(s) ______________________________ Date ______________

______________________________ County ______________

______________________________ Weather ______________

Site/Project Name ____Site

Location/Address ____

1. **CONDITIONS ADJACENT TO WETLAND** (within 200 feet)

A. Name of Basin ______________________

B. **SIZE OF BASIN**

	Large	Medium	Small
Size of Basin			

C. **LOCATION OF WETLAND IN BASIN**

	Upper third	Middle third	Lower third
Location of wetland in basin			

D. **CURRENT LAND USE ADJACENT TO WETLAND**

Zoning	Use	Percent	Comments/Conditions
Residential			
single family			
multi family			
Commercial			
Industrial			
Business Park			
Agriculture			
Native Vegetation			

E. Historical Land Use Adjacent to Wetland. How was this assessed?

2. **EXISTING WETLAND TYPE AND SIZE** (non-compensation wetland)

A. **EXISTING WETLAND TYPE AND SIZE**

Community Type	Percent Total Wetland	Size of Wetland (Acres)
POW		
PEM		
PSS		
PFO		
PAB		

DOE Wetland Category:

B. **EXISTING WETLAND VEGETATION**

Strata	Species (listed by dominance)
Canopy	
Subcanopy	
Shrubs	
Herbs	
Grasses/Sedges	

3. **BUFFER CHARACTERISTICS** (within approximately 200 feet of wetland edge)

A. **BUFFER CHARACTERISTICS**

	Pre-existing	Required	Current
Slopes			
Intrusions (i.e. humans, runoff, pets)			
Sp. Complexity (low, med, hi)			
Comm. Complexity (low, med, hi)			

B. Date of Construction or Permit (i.e. age of buffer):

C. **BUFFER DIMENSIONS**

Percentage, Condition and Dimension of Buffer Type	Pre-existing	Permit Requirements	Existing
Forest			
Shrub			
Pasture			
Landscaping/ Grasses			
Residential			
Business Park			
Industrial			
Paved Surface			

4. WETLAND AND BUFFER CONDITIONS

A. WETLAND/BUFFER CONDITIONS

	WETLAND Yes	WETLAND No	BUFFER Yes	BUFFER No	Specifics/Comments
Runoff					
point source					
non-point source					
chemical					
physical					
Turbidity in Wetland					
Oil/Grease					
Erosion					
Siltation (L,M,H)					
Wildlife Use					
birds					
mammals					
fish					
amphs/repts					
prey species					
Habitat Features					
snags/cavities					
brush/cover					
food species					
veg. complexity					

B. Are there impacts to the installed buffer? Y / N Describe:

C. What was the probable source of adverse impacts to the buffer?

D. Are there impacts to the wetland? Probable source:

E. Are the impacts to the wetland correlated to:

a) impacts to the buffer?
b) presence/absence of the buffer?
c) condition (size/type) of the buffer?

Describe:

F. Were the requirements met? Y / N Describe:

5. BUFFER FUNCTIONS

A. **BUFFER FUNCTIONS**

Buffer Functions	Pre-existing	Goal	Current
Biofiltration/sediment			
Nutrient Uptake			
Habitat Diversity			
Protection from Intrusion			
Flood Storage			
Wetland and Surficial Ground Water Recharge			

B. Are the functional purposes evident?

C. Were buffer goals appropriate, attainable, realistic?

7. SUMMARY

A. What appears to be functioning properly on this site, what does not function on this site?

B. General comments on buffer effectiveness.

C. Suggestions for increasing buffer functioning?

Additional Comments:

Attachment 3 - FIELD FORM METHODOLOGY

The buffer data sheets were designed to collect consistent information on each site regarding pre-existing conditions, permit requirements, design goals and objectives, existing site conditions, and qualitative assessments of success and functioning of the buffer. Data sheets were structured to collect both permit file and field data, however all portions of the field data sheets were recorded on site.

Preliminary information was entered into the data sheet before proceeding to the remainder. This information included investigators name(s), date, site name and site location.

Section 1 was designed to assess permit requirements and conditions present before the surrounding land use was changed (development installed). This information was obtained primarily from the permit files, however in several cases where the investigator was familiar with the site, the information was known.

Pre-existing wetland community types were identified (according to the Cowardin classification), as well as the dominant species present in each strata, if known. This information was obtained from the descriptions of pre-existing site conditions in the permit files.

Sections 2 and 3 were designed to describe the existing buffer and wetland details. Soils, and vegetation and structure aspects were described. This information was also obtained from the permit files.

Section 4 was designed to assess land use within 200 feet of the wetland, and the wetland itself. Basin information can be obtained from USGS topographic maps. Current land use was identified by viewing at the surrounding area.

Wildlife habitat features such as snags, logs, beaver dams, brush, and forage were noted. Actual wildlife use was identified on the basis of observed wildlife, tracks, holes or nests. Some assumptions regarding wildlife use were made based on site conditions. Additional detail was provided when needed.

Section 5 addresses buffer functions past goals for the buffer after implementation of the project, and current.

Several questions in sections 4 and 5 were designed to elicit the opinion of the investigators as to the appropriateness of the various aspects of the buffer. This was strictly an assessment based on the investigators expertise and site conditions.

Section 6 is a summary section. Probable factors affecting buffer and compensation wetland functioning were identified and a general analysis of the wetland system was given. This section provided an opportunity for further comments not solicited from specific questions on the form.

<u>Attachment 4</u> - SPECIES LIST

Plant Species Key

Trees

ACERMACR - Acer macrophyllum - Big Leaf Maple
ALNURUBR - Alnus rubra - Red Alder
FRAXLATI - Fraxinus latifolia - Ash
PICESITC - Picea sitchensis - Sitka Spruce
POPUTREM - Populus tremuloides - Trembling Aspen
POPUTRIC - Populus trichocarpa - Western Cottonwood
PSEUMENZ - Pseudotsuga menziesii - Douglas' Fir
RHAMPURS - Rhamnus purshiana - Cascara (Buckthorn)
THUJPLIC - Thuja plicata - Western Red Cedar
TSUGHETE - Tsuga heterophylla - Lowland Hemlock

Shrubs

ACERCIRC - Acer circinatum - Vine Maple
BERBNERV - Berberis nervosa - Cascade Oregon Grape
CORNSTOL - Cornus stolonifera - Red Osier Dogwood
CORYCORN - Corylus cornuta - Hazelnut
CRAE - Crataegus spp. - Hawthorne
CYSTSCOP - Cytisus scoparius - Scott's Broom
GAULSHAL - Gaultheria shallon - Salal
HOLODISC - Holodiscus discolor - Oceanspray
ILEXAQUI - Ilex aquifolium - English Holly
LEDUGROE - Ledum groenlandicum - Bog Labrador Tea
LONIINVO - Lonicera involucrata - Black Twin-berry
MENZFERR - Menziesia ferruginea - Fool's Huckleberry
OEMLCERA - Oemleria cerasiformis - Indian Plum
PRUNEMAR - Prunus emarginata - Bittercherry
PYRUFUSC - Pyrus fusca - Ninebark
RIBEBRACT- Ribes bracteosum - Common Current
RIBESANG - Ribes sanguineum - Red Current
ROSAGYMN - Rosa gymnocarpa - Little Wild Rose
ROSAPISO - Rosa pisocarpa - Clustered Wild Rose
RUBUDISC - Rubus discolor - Himalayan Blackberry
RUBULASI - Rubus laciniatus - Evergreen Blackberry
RUBUPARV - Rubus parviflorus - Thimbleberry
RUBUSPEC - Rubus spectablilis - Salmonberry
RUBUURSI - Rubus ursinus - Dewberry
SALILASI - Salix lasiandra - Pacific Willow

SALIPEDI - Salix pedicellaris - Bog Willow
SALISCOU - Salix scoulerleriana - Scouler's Willow
SALISITC - Salix sitchensis - Sitka Willow
SAMBRACE - Sambucus racemosa - Red Elderberry
SORBAMER - Sorbus aucuparia - European Mountain Ash
SORBSCOP - Sorbus scopulina - Cascade Mountain Ash
SPIRDOUG - Spirea douglasii - Douglas' Hardhack
SYMPALBA - Symphoricarpos albus - Snowberry
TAXUBREV - Taxus brevifolia - Pacific Yew
VACCOXYC - Vaccinium oxycoccos - Bog Cranberry
VACCPARV - Vaccinium parvifolium - Red Huckleberry
VACCSCOP - Vaccinium scoparium - Whortleberry

Ferns/Horsetails

ATHYFELI - Athyrium felix-femina - Lady Fern
BLECSPIC - Blechnum spicant - Deer Fern
DRYOAUST - Dryopteris austriaca - Mountain Woodfern
EQUIARVE - Equisetum arvense - Common Horsetail
EQUIHYEM - Equisetum hyemale - Common Scouring Rush
EQUITELMA- Equisetum telmateia - Giant Horsetail

Herbs

ACTERUBR - Actea rubra - Bane Berry
ANAPMARG - Anaphalis margaritacea - Pearley Everlasting
BIDECERN - Bidens cernua - Nodding Beggar-tick
CIRCARVE - Circium arvense - Canada Thistle
CLAYLANC - Claytonia lanceolata - Western Spring Beauty
CONVSEPI - Convolvus sepium - Hedge Bindweed
DICEFORM - Dicentra formosa - Bleeding Heart
DIGIPURP - Digitalis purpurea - Foxglove
EPILANGU - Epilobium angustifolium - Fireweed
EPILWATS - Epilobium watsonii - Watson's Fireweed
GALI - Galium spp. - Bedstraw
GALITRIF - Galium trifidum - Small Bedstraw
GEUMMACR - Geum macrophyllum - Bigleaf Cinquefoil
GNAPULIG - Gnaphalium uliginosum - Marsh Cudweed
GYMNDRYO - Gymnocarpium dryopteris - Oakfern
HEDEHELI - Hedera helix - English Ivy
HIERNUDI - Hieracium spp. - Hawkweed
HYPEFORM - Hypericum formosum - Western St.Johnswort
HYPEPERF - Hypericum perforatum - Common St.Johnswort
IMPA - Imaptiens spp.- Touch-Me-Not
IRISPSEU - Iris pseudachorus - Yellow Flag
LEMNMINO - Lemna minor - Water Lentil (Duck weed)

LICH - Lichen spp.
LINNBORE - Linnaea borealis - Twin Flower
LOTUCORN - Lotus corniculatis - Bird'sfoot Trefoil
LUDWPALU - Ludwigia palustris - Water Purslane
LYSIAMER - Lysichitum americanum - Western Skunk Cabbage
MAIADILA - Maianthemum dilatatum - False Lily of the Valley
MENYTRIF - Menyanthes trifoliata - Bogbean
MIMUGUTT - Mimulus guttatus - Yellow Monkeyflower
MONTSIBE - Montia siberica - Western Springbeauty
MUSC - Musci spp. - Moss
MYOSLAXA - Myosotis laxa - Small Flowered Forget-me-not
NUPHPOLY - Nuphar polysepalum - Yelloy Pond Lily
OENASARM - Oenanthe sarmentosa - Water Parsley
OPLOHORR - Oplopanax horridum - Devil's Club
PETASAGI - Petasites sasgittatus - Colt's Foot
PLANLANC - Plantago lanceolata - English Plantain
PLANMACR - Plantago macrocarpa - Alaska Plantain
PLANMAJO - Plantago major - Common Plantain
POLYGLYC - Polypodium glycyrrhiza - Polypody Fern
POLYHYDR - Polygonum hydropiper - Marshpepper Smartweed
POLYMUNI - Polystichum munitum - Sword Fern
POTANATA - Potamogeton natans - Floating-leaved Pondweed
POTEPALU - Potentilla palustris - Marsh Cinquefoil
PTERAQUI - Pteridium aquilinum - Braken Fern
RANUREPE - Ranunculus repens - Creeping Buttercup
RORI - Rorippa spp. - Watercress
RUMECRIS - Rumex crispus - Curley Dock
SCUTLATE - Scutellaria lateriflora - Mad-dog Scutellaria
SMIL - Smilacina spp. - False Solomon's Seal
SOLADULC - Solanum dulcamara - Deadly Nightshade
SPAREMER - Sparganium emersum - Simple-stem Bur-reed
SPAREURO - Sparganium eurycarpum - Broad-fruited Bur-reed
SPHA - Sphagnum spp. - Sphagnum Moss
STACCOOL - Stachys cooleyae - Stachys' Horse-mint
STELMEDI - Stellaria media - Chickweed
TREAMPL - Streptopus amplexifolius - Clasping-leaved Twisted-stalk
TIARTRIF - Tiarella trifoliata - Foamflower
TOLMMENZ - Tolmiea menziesii - Pig-a-Back Plant
TRILOVAT - Trilliumn ovatum - Western White Trillium
TYPHLATI - Typha latifolia - Cattail
URTIDIOI - Urtica dioica - Stinging Nettle
URTILYAL - Urtica dioica var.lyallii - Lyal's Nettle
UTRIMINO - Utricularia minor - Lesser Bladderwort
UTRIVULG - Utricularia vulgaris - Greater Bladderwort

VEROAMER - Veronica amnericana - American Brooklime
VEROSCUT - Veronica scutellata - Marsh Speedwell
VIOL - Viola spp. - Violet

Grasses/Sedges and Rushes

AGROSCAB - Agrostis scabra - Winter Bentgrass
AGROTENU - Agrostis tenuis - Colonial Bentgrass
ALOPAQUI - Alopecurus aquatilis - Common Timothy
ALOPPRAT - Alopecurus pratensis- Water Timothy
CAREAQUA - Carex aquatilis - Water Sedge
CAREARCT - Carex arcta - Clustered Sedge
CAREATHR - Carex athrostachya
CARELAEV - Carex laeviculmis - Smooth Stem Sedge
CAREOBNU - Carex obnupta - Slough Sedge
CAREPARV - Carex parryana - Parry Sedge
CAREPAUC - Carex pauciflora - Few-flowered Sedge
CAREROST - Carex rostrata -
CARETUMI - Carex tumulicola - Foothill Sedge
CAREUNIL - Carex unilateralis - One-sided Sedge
CAREVESI - Carex vesicaria - Inflated Sedge
DACTGLOM - Dactylis glomerata - Orchard Grass
ELEOOVAT - Eleocharis ovata - Ovoid Spikerush
ELEOPALU - Eleocharis palustris - Common Spikerush
FESTRUBR - Festuca rubra - Red Fescue
GLYCELAT - Glyceria spp. - Mannagrass
GLYCGRAN - Glyceria grandis - Reed Mannagrass
HOLCLANA - Holcus lanatus - Common Velvetgrass
JUNCACUM - Juncus acuminatus - Tapered Rush
JUNCBUFF - Juncus bufonius - Toad Rush
JUNCEFFU - Juncus effusus - Soft Rush
JUNCENSI - Juncus ensifolius - Dagger-leaf Rush
JUNCTENU - Juncus tenuis - Slender Rush
JUNCUNIC - Juncus unicialis - NCN
LOLIPALU - Lolium palustriis - Perennial Ryegrass
LUZUPARV - Luzula parviflora - Small-flowered Woodrush
PHALARUN - Phalaris arundinaceae - Reed Canary Grass
PHLEPRAT - Phleum pratense - Timothy
POAPALU - Poa palustris - Fowl Bluegrass
POAPRAT - Poa pratensis - Kentucky Bluegrass
PUCCPAUC - Puccinellia pauciflora - Small-Flowered Puccinellia
SCIRCYPE - Scirpus cyperinus - Wool-grass
SCIRMACR - Scirpus microcarpus - Small-fruited Bullrush

Attachment 5 - BUFFER SITE COMPLETED FIELD FORMS

(species eight letter codes are found in Attachment 3)

BUFFER SITE #1 **LOCATION:** 84th Ave W and 220-224th St SW Snohomish
STR: /27N/4E THOMAS BROS. PAGE: 58 DRAINAGE: Lake Ballinger

TYPE OF LAND USE CHANGE: Created wetland to east.

PRE-EXISTING SITE CONDITIONS: Sphagnum bog; some open water; few residences to west; a road cutting the wetland in half; second half of bog filled. Bog receiving stormwater runoff from nearby houses.

CURRENT ADJACENT LAND USE: 75% single family residential, 25% native vegetation.

BUFFER REQUIREMENTS: None required; none set by NGPE to protect bog wetland from runoff from west and east; protect bog wetland from physical disturbance (bog is degrading from trampling).

BUFFER DIMENSIONS? Various, 10% PSS 6 to 10 feet, 10% shrubs and garbage. Along road (30%) - 0 feet, to west (40%) - 200+ feet, to east - 150+ feet, to north and south - 25 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1989-90

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: Slopes 4:1; species complexity high; community complexity medium; filled in portion currently restored to POW/PEM/PSS. The buffers are functioning as variably as their widths. There is no buffer along the road. Road runoff enters the wetland directly, presumably adding a high heavy metal load and changing the pH. The buffer to the north is functioning because there is a physical barrier, and stormwater is diverted to other directions. The buffer to the west is 500+ feet and is functioning well as there is very little evidence of disturbance to the wetland from this direction. The buffer to the south allows people to enter, and this is has resulted in paths being established in the buffer.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: Two+ acres total, 70% POW, 10% PEM, 20% PSS. The bog is dying as a result of past inputs of stormwater. Category 1 wetland. There is a heavy Potentilla Palustris infestation of the floating mat, which is taking over the mat community. It is not known if the new buffer and the created wetland across the road will help in treating the wetland, help to re-establish the pH, and decrease the heavy metal content. The physical disturbance from people entering the wetland from the south is causing degradation along the foot path. Runoff= point and non-point, chemical, siltation, turbidity, oil, grease. Wildlife= birds, mammals, amphibians. Habitat= snags, brush/cover, complex vegetation. Vegetation= Thujplic, Tsughete, Pinumont, Sali scou, Salilasi/ Kalmmicr, Ledugroe, Spirdoug, Potenate, Nuphpoly, Patepalu, Drosrotu, Sphag, Vaccoxyc, Careobnu, Eriospp, Junceffu.

CRITICAL COMPONENTS OF FUNCTIONING: Protection from physical disturbance along east, north and west sides of the wetland. Protection from stormwater inputs from the residences to the west, and the road that bisects the wetlands north/south.

WERE THE BUFFER GOALS MET? Partially; variable as the buffer types and widths for the most part; the physical disturbance to the north is gone, the disturbance to the south is quite bad and the bog community is degrading quite badly. The stormwater inputs from the west are probably no longer a problem as they are being treated in the created wetland.

BUFFER SITE #2 **LOCATION:** 127 St SW and 55 Ave W, Snohomish
STR: /28 N/4E THOMAS BROS. PAGE: 48 DRAINAGE: Lake Serene?

TYPE OF LAND USE CHANGE: Single family residential development

PRE-EXISTING SITE CONDITIONS: Diverse vegetation communities, wetland mosaic of POW, PSS, and PFO. Slopes were steeper 3:1. Upland buffer was less developed and had up to 50% native vegetation.

CURRENT ADJACENT LAND USE: 90% single family residential, 10% native vegetation

BUFFER REQUIREMENTS: Not located

BUFFER DIMENSIONS? Various, 0 to 20 feet throughout

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987-1989

IMPLEMENTED AS PLANNED? As far as can be determined, yes.

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: Slopes 2:1 for 50%, 3:1 for 50%. Human, dogs intrusion into buffer, a structured outlet built into the wetland; species complexity med to low given many community types, community complexity high. (5%) yard waste and debris, (85%) grass lawn fencing and beauty bark, (10%) planted native shrubs; runoff= fertilizer inputs, oil and grease, small amount of siltation occurring non-point and physical inputs via landscaping debris; wildlife= bullfrogs, and domesticated animals, little to no small mammal, few birds, no fish visible; habitat features= snags, brush, and food species (willows, crab apples).

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: Two to five acres of mixed POW (40%), PEM (10%), PSS (30%), and PFO (20%); probably a Category 2 wetland; vegetation= Alnurubu, Thujplic, Tsughete, Spirdoug, Salispp, Pyrufusc, Lemnmino, Ludwpalu, Scirmicro, Junceffu, Irispseu, Typhlati, Agrospp, Juncensi, Oenasarm, Carerost

CRITICAL COMPONENTS OF FUNCTIONING: Little or no protection from either physical disturbance as lawn beckons people to the wetlands edge, or from stormwater inputs as grass acts little to absorb toxicants and the buffer is fertilized lawn. Overflow from the road enters the edge directly so siltation is likely a problem during large storm events. Impacts to the wetland are apparent from the low species diversity on the edge, algal blooms, siltation, and presence of garbage around the edge.

WERE THE BUFFER GOALS MET? For the most part, no. The buffer is highly modified and currently contains debris. The wetland shows some signs of impact which are expected to get worse. Impacts are due to impacts to the buffer itself, the lack of buffer in some places, and the inadequate size of the buffer in others.

BUFFER SITE #3 LOCATION: 112th Ave NE and 108th Ave NE between 155 and 158th St. King County
STR: 17/26/5E THOMAS BROS. PAGE: 4 DRAINAGE: Juanita Creek

TYPE OF LAND USE CHANGE: Five large single family residential units

PRE-EXISTING SITE CONDITIONS: 60-year, second growth forest (mixed deciduous/coniferous) bordering 19 acre scrub/shrub wetland that grades into Lake Washington.

CURRENT ADJACENT LAND USE: Surrounding land use= 60% residential (80% single family, 20% multi-family), and 40% native vegetation. Site is an abandoned farm.

BUFFER REQUIREMENTS: 50-foot buffer required, allowed development right to edge of wetland

BUFFER DIMENSIONS: Various, 10 to 100 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? fall 1989

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: Not only no buffer, but first 20 feet of wetland are acting as a buffer for the rest of the wetland. Highly impacted. Residents are cutting down trees for view, yard debris is being deposited, back yards extend into the wetland; 20% forested, 65% residential, 10% lawns and 5% paved surface; there is a trail that runs along the margin of the wetland which gives access for humans and pets into the wetland; species complexity is low to moderate, community complexity is low to moderate; impacts to the buffer include clearing, invasion by pets, a walkway within the buffer, fill, and storm drain construction.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 2.5 acres total, 50% PEM, 50% PSS/PFO. Invasive species are out-competing natural vegetation (Rubudisc replacing COST, Salispp) Vegetation= Alnurubu, Oemlcera, Rubuspec, Rubudisc, Salispp, Spridoug, Typhlati, Veroamer, Ranurepe, Equiarve, Agrospp, Junceffu, Holcspp, Scirmicro, Phalarun, Ludwpalu. Runoff= non-point, small chemical and physical disturbance, some turbidity in water, oil and grease present, high siltation in places. Wildlife use= low on the south side, moderate to high for birds, mammals, amphibians. Habitat features= snags, brush/cover, food species, and vegetation complexity.

CRITICAL COMPONENTS OF FUNCTIONING: Siltation is occurring from the stream channel at the top of the property. The stream has been channelized and placed through a culvert into and out of the wetland. There is obvious decreased water quality and habitat complexity resulting from both lack of buffer and type of buffer, where present (lawn). Fences have been built into the buffer and yard waste thrown over them just out of sight. Access into the buffer and wetland via the path that runs adjacent to the wetland. This encourages human and pet intrusion. Wetland and buffer degradation has occurred since 1988.

WERE THE BUFFER GOALS MET? The buffer is acting as biofiltration and nutrient uptake for part of its length, habitat diversity is maintained for 1/3 of the diameter of the wetland, not much but some help, physical intrusion is blocked by fences and in thick vegetation zone, however entrance can occur at other points. Goals to the south along the road were to build a 10-foot grassy walkaway. In this instance the goal was met, but was unrealistic in terms of buffering the wetland from any negative impact. Setbacks for the houses should not have been included in the lots, and trails should not have been built in the buffer.

BUFFER SITE #4 **LOCATION:** Inglewood Rd. and NE 165th St King County

STR: 11/26/4E THOMAS BROS. PAGE: 3 DRAINAGE: East Lake Washington

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TYPE OF LAND USE CHANGE: Single family residential, 5 units built

PRE-EXISTING SITE CONDITIONS: A scrub-shrub wetland contiguous to Lake Washington. The buffer to the south was old growth black cottonwood, willow, and big leaf maple. The wetland has been receiving nutrient-rich overflow from an adjacent golf course for many years.

CURRENT ADJACENT LAND USE: 25% single family residential, 25% multifamily residential, 25% road edge adjacent to a golf course, 25% adjacent to Lake Washington

BUFFER REQUIREMENTS: None set. There were no setback requirements established for this project.

BUFFER DIMENSIONS: Various, 0 feet along the southern boundary, 5 to 10 feet along the eastern boundary, the Lake to the west, and 0 feet to the north where there is an existing multifamily residential unit.

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? Fall 1988, winter 1989

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: 25% open lake, no buffer to north or south where there are high density single family and multifamily residences. The edge of the wetland is acting as the buffer to the rest of the wetland. Yard debris and fill is being deposited, trees are being cut down for a view, invasive vegetation (Himalayan blackberry) is taking over. The wetland is being mowed and ornamental species are planted in the wetland on the north side. The road to the east and the ten-foot buffer strip are not large enough to filter sediments, oil and grease, point and non-point source pollution, and nutrients that come off the golf course. Wildlife non-existent except for rats.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 9.5 acres. (15%) PEM, (30%) PFO, (65%) PSS, plus adjacent to Lake edge. Possible Category 2 wetland. There is a high impact from the residents to the north and south where physical damage is occurring from cutting down of trees, removal of shrubs, deposition of yard waste, invasion by blackberry. The shifting of the water table such that ten very large trees fell down within a year of the development going in. Runoff=chemical inputs, mostly nutrients that come off the golf course, sedimentation, oil and grease, point and non-point source pollution. Wildlife use= birds, mammals, amphibians, prey species and possibly fish. Habitat features= few snags, high brush/cover, high food species, and vegetation complexity. Vegetation= Poputric, Alnurubu, Salilasi, Saliscou, Salisitc, Cornstol, Oemlcera, Loniinvo, Rubuspec, Rubudisc, Spirdoug, Tolmmenz, Ranurepe, Scirmicro, Phalarun, Carespp..

CRITICAL COMPONENTS OF FUNCTIONING: The wetland is currently functioning as the buffer to the rest of the wetland. The residents appear to consider the wetland edge their property for placing debris, and cutting down trees.

WERE THE BUFFER GOALS MET? No, because there were no buffer goals established. There is no buffer for a large portion of the site.

BUFFER SITE #5 LOCATION: 134-135 Ave NE, and NE 187-190 St. King County
STR: 3/26N/5E THOMAS BROS. PAGE: 4 DRAINAGE: Bear Creek

TYPE OF LAND USE CHANGE: Several units of single family residences.

PRE-EXISTING SITE CONDITIONS: Unknown, except that a portion likely was native vegetation.

CURRENT ADJACENT LAND USE: 40% single family residential, 60% native vegetation

BUFFER REQUIREMENTS: 50-foot throughout

BUFFER DIMENSIONS: Various, 0 to 50

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1986

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: There is minimal species or community complexity in the 50-foot buffer and no vegetation along the edge of a gravel road also included in the 50-foot buffer. Runoff= point and non-point, chemicals. Wildlife use is moderate to high for birds, and low for mammals. Bush cover habitat is high and there are a few snags, but food species and vegetation complexity are both low. There has been repeated dumping of debris, both lawn waste and refuse. There has also been some filling in the buffer. Portions of the buffer act to trap sediment and nutrients, but this capacity is low, protection from intrusion is variable and flood storage and groundwater recharge is minimal. Dumping is a problem. The development has altered the hydrology and there is lots of tree death.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 15 to 20% POW, 80 to 85% PSS acreage unknown wetland, probably Category 2. There are some definite negative impacts to the wetland resulting from dumping, filling, landscaping, and allowing runoff to directly enter the wetland. Runoff= point and non-point source, chemical (nutrients from fertilizer, road runoff (heavy metals). Wildlife= mammals, fish, amphibians, and prey species. Habitat features= few snags, many brush/cover possibilities, lots of food species, and the vegetation complexity is moderate to high. Vegetation= Salispp, Spridoug, Potepalu, Phalarun.

CRITICAL COMPONENTS OF FUNCTIONING: The gravel road along the edge of the wetland offers no real buffering capacity. The wetland is receiving runoff with elevated nutrient contents directly from the lots. Species richness in the buffer is lacking and the back side of a few of the lots no longer has the 50-foot buffer left. The lots have claimed the area for lawn and now mow the area constantly. The variable buffer width and the type of buffer implemented seem to be the cause for the non-functioning of the buffer. Stormwater and physical disturbance are reaching the wetland via the sections of the buffer that are non-existent or greatly reduced, or are of less capacity for functioning as a buffer (gravel road).

WERE THE BUFFER GOALS MET? Some of the buffer goals were met initially, but over time these have been limited and it is projected that the buffer functioning will decrease even more over time, as increased urban pressure is met. A 50-foot buffer was not maintained over time. The wetland looks good despite the many limits to the buffer. Enforcement of buffers would really help here as well as policing the dumping. Some of the buffer should be increased in size, or made into more protective buffer communities (e.g., shrub). NGPE should be taken out of private hands. The plat requirements were in conflict with resource protection requirements.

BUFFER SITE #6 **LOCATION:** 189-196 Ave NE and Snohomish City line and NE 202 St. King County
STR: 6/26N/6E THOMAS BROS. PAGE 5 DRAINAGE: Bear/ Evans Creek

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TYPE OF LAND USE CHANGE: Construction of many single family lots

PRE-EXISTING SITE CONDITIONS: Old second growth forested almost 100%

CURRENT ADJACENT LAND USE: 85% single family residential, 15% native vegetation.

BUFFER REQUIREMENTS: 50+ feet, oil separators and R/D ponds not in the buffer.

BUFFER DIMENSIONS: Various, greater than 50 feet in general. 50+ feet in forested area, with 15% of the buffer 15-foot paved road setback.

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The species and community complexity is moderate to high. There is runoff into the buffer from street. The buffer looks intact and not impacted to a large degree. No visible debris, but there is cutting of trees.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 80% PSS, 20% PFO wetland is approximately 2 acres in size, a Category 3 wetland. The wetland is healthy and shows little impact from surrounding development. Runoff is point source from stormwater placed through a culvert. Wildlife use= moderate bird, small mammal, and amphibian use. Habitat features include snags, brush/cover, food species, and vegetation complexity. Vegetation= Thujplic, Alnurubu, Rubuspec, Pyrufusc, Loniinvo, Gaulshal, Potenate, Ranurepe.

CRITICAL COMPONENTS OF FUNCTIONING: The buffer is functioning for biofiltration, nutrient uptake from adjacent lots, habitat diversity, and protection from intrusion. Flood storage is not really an issue, but the wetland is a basin and could act in this capacity, too. One factor which may contribute to of the lack of debris is the high cost of the homes, and the point that most houses appear to have landscaping services that remove the debris to off-site locations.

WERE THE BUFFER GOALS MET? Yes. They were not only met, but are providing the best protection seen for this study. There has been no visible degradation since the 1988 study.

BUFFER SITE #7 **LOCATION:** NE Novelty Hill Rd. and 212 E and 220th Ave NE, King County
STR: 33/26N/6E **THOMAS BROS. PAGE:** 11 **DRAINAGE:** Bear-Evans Creek

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TYPE OF LAND USE CHANGE: High density single family residences

PRE-EXISTING SITE CONDITIONS: 100% forested, old, second growth with moderate to high species and community complexity.

CURRENT ADJACENT LAND USE: 100% single family homes, small lots

BUFFER REQUIREMENTS: 30 feet

BUFFER DIMENSIONS: Various, 15-foot beauty bark setback from the wetland edge and road, low species or community complexity. Zero to 100 feet in areas that are landscaped, 0 to 50 feet on the back of the residential lots.

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1988

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: Sediment entrapment, few domestic animals, but no signs of wildlife, no birds, amphibians, or small mammals. Where there is vegetation in the buffer, the species are complex. The buffer has been removed in some places, or the underbrush has been removed and beauty bark placed in its stead.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 100% PFO, mixed conifer and deciduous wetlands restricted to thin corridors. Runoff= point and non-point source carrying nutrients and stormwater, siltation is high. Wildlife use is limited to a few birds, and dogs and cats. Habitat features in the wetland are a few snags, some brush for cover, and low species complexity. Vegetation= Thujplic, Tsughete, Alnurubu, Rubuspec, Gaulshal, Oemlcera, Lysiamer, Ranurepe, Oenasarm, Scirmicr.

CRITICAL COMPONENTS OF FUNCTIONING: The buffer is failing to function because it does not exist for a large portion of the area surrounding the wetland. Biofiltration is low, nutrient uptake is low, habitat diversity is low, no protection from intrusion, flood storage is good because located in a basin. There is no noise screening from the Novelty Hill road and wildlife doesn't appear to use the site. There is physical damage due to deposition of debris and garbage. There is nutrient input into the wetland from lawn fertilizer service.

WERE THE BUFFER GOALS MET? No. The requirements set by the NGPE were too small to adequately protect the wetland from the density of the lots. Many of the lots had the buffer incorporated into the back of the lot. These have since been made lawn and are now included into the property. Much wetland area has been lost since the 1990 inventory. The lots are located on steep banks that are adjacent to the wetland edge. Lack of a buffer and steepness of slope has made erosion a problem, so siltation is high. Cement trucks have cleaned out into the wetland in two areas. There is a need for enforcement after construction, and an inspector on site during development. Comparison to 1988 study shows continued heavy siltation, continued removal of buffer, because very few of the houses were in at the time.

BUFFER SITE #8 **LOCATION:** NE 133 and NE 145th and 214-228 Ave NE, King County
STR:21/26N/6E THOMAS BROS. PAGE: 12 DRAINAGE: Bear Creek

TYPE OF LAND USE CHANGE: Phased of units of single family residences, medium density.

PRE-EXISTING SITE CONDITIONS: Medium age second growth forest, some newly logged, (late 70s interspersed with wetlands (BBC 25,26,27), some large, some small.

CURRENT ADJACENT LAND USE: 95% single family, 5% native vegetation, near phase 1 of the development.

BUFFER REQUIREMENTS: 50 feet, fences off the lots abutting the water, and an educational brochure to be given to residents explaining the wetlands and their value.

BUFFER DIMENSIONS: Various, 50 to 200 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The buffer does not receive runoff. It does offer a diverse vegetation community so there is habitat for birds, small mammals and limited amphibian populations. There are a few snags, and lots of brush for cover. The buffer is cleared in some places to the lakes' edge. There are deposits of yard debris along the bottom of many lots. There is a path that has been cut throughout the buffer edge around the lake. This enables people and pets to access the wetland directly.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: BBC27= 80% POW, 20% PSS, 16.5 acres in size. The wetland is a likely a Category 2 wetland. There is impact in the wetland due to runoff problems, siltation, turbidity, etc. Runoff= point and non-point source inputs of nutrients and stormwater. There is some siltation, and a minor amount of turbidity, although both have been a problem during the different construction phases. Wildlife use includes birds and some amphibians. There are a few snags, and shrubs, and there are many food species growing in the wetland. Vegetation complexity in the wetland is low because so much of the area is open water. Vegetation= Alnurubu, Oemlcera, Rubuspec, Ranurepe, Scirmicro.

CRITICAL COMPONENTS OF FUNCTIONING: There is biofiltration, nutrient uptake, habitat diversity from diverse community left, flood storage because the wetland is in a basin.

WERE THE BUFFER GOALS MET? Not for stormwater intrusion and sedimentation, but yes for everything else. Prevention of intrusion would be hard to do even given a 200-foot buffer. The only solution would be to fence off the wetland from access.

BUFFER SITE #9 LOCATION: 224 Ave NE and Union Hill Rd., King County
STR: 9/25N/6E **THOMAS BROS. PAGE:** 17 **DRAINAGE:** Evans Creek

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TYPE OF LAND USE CHANGE: Construction of many lots of single family residential units.

PRE-EXISTING SITE CONDITIONS:

CURRENT ADJACENT LAND USE: 70% single family residential units, 30% native vegetation (young second growth).

BUFFER REQUIREMENTS: 50 feet

BUFFER DIMENSIONS: Various, 0 to 100 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? Mostly yes. There were a few small areas where the NGPE was cleared but mostly as planned.

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The buffer varies from lawns to multi-canopy communities. Forested, shrub and residential areas are all included in the buffer. There is some landscaping debris left all over the site. The buffer receives point and non-point source runoff which is nutrient and road runoff laden. The buffer is mowed for about 25% of its length. There are signs of domestic animals, birds and small mammals. There is a diverse habitat with many snags, brush for cover and food species.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 70% PFO mixed conifer hardwoods, 15% PEM cattail, enhanced R/D pond, 15% PSS. The buffer has been removed in some areas and there is no buffer left between the wetland and the houses. The presence of simple lawn buffers does little to fulfill many of the attributes. Lawns abut the wetland and landscaping debris is thrown into the wetland. The R/D pond receives too much nutrient laden water from the commercial lawn care companies and it is loaded with algae. Vegetation= Thujplic, Alnurubu, Tsughete, Acermacr, Rubuspec, Oemlcera, Loniinvo, Ribespp, Typhlati, Veroamer, Oenasarm, Scirmicr.

CRITICAL COMPONENTS OF FUNCTIONING: The buffer is currently functioning to act as biofiltration and nutrient uptake for most of the stormwater that passes into the wetland. This does not work for those areas where the buffer has been removed. It also acts for flood storage

WERE THE BUFFER GOALS MET? The goals were met but they were too simplistic. There is little community complexity to offer diverse habitat for wildlife. The buffers were placed in the lots and over time many of the homeowners have leveled the buffer and made more lawn out of the area. The rest of the buffer looks good. The R/D ponds look sufficiently large to contain large storm events. Water quality has improved since 1988 after construction. The amount of siltation has decreased.

BUFFER SITE #10 **LOCATION:** 221St and 225 Ave NE , and NE 16-20th St., King County
STR: 28/25N/6E THOMAS BROS. PAGE: 23 DRAINAGE: Evans Creek

TYPE OF LAND USE CHANGE: High density single family residences

PRE-EXISTING SITE CONDITIONS:

CURRENT ADJACENT LAND USE: 100% small lot single family residences

BUFFER REQUIREMENTS: 50-foot

BUFFER DIMENSIONS: Various, 0 to 50-foot buffer

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: There are steep slopes (60 to 80 degree), low species complexity, and moderate community complexity. Forested, grass landscaping and residential areas to buffer. Erosion is a factor because of the steepness of the slopes. The forested areas has some wildlife habitat value because of a few snags, and some brush for cover. The buffer has been impacted by removal over time of that portion which was included in the lots. Portions are now grassy lawn.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 100% PFO. Acreage less than 10 acres and is a Category 2 wetland. The wetland has been impacted over time by channelizing the stream that flows through it. Vegetation species complexity has been lost as a result of the loss of buffer. The wetland is now completely surrounded by homes. Much landscaping debris has been deposited into the wetland over time. Vegetation= Thujplic, Tsughete, Acermacr, Rubuspec, Cornstol, Acercirc, Spirdoug, Sambrace, Vaccparv.

CRITICAL COMPONENTS OF FUNCTIONING: The buffer no longer acts for biofiltration or removal of fertilizer amendments. There is marginal habitat diversity, and the protection from intrusion is afforded only by the steepness of the slope, not the buffer itself. There are no flood storage or recharge functions.

WERE THE BUFFER GOALS MET? Yes, but these goals were not sufficient to ensure maintenance of the wetland in an unaltered state. The wetland was in effect "hidden" behind the houses. There should have been an additional 50 to 100 feet of buffer left beyond the lots.

BUFFER SITE #11 **LOCATION:** NE 16 and 20th, and 221-225 Ave NE, King County
STR: 28/25N/6E **THOMAS BROS. PAGE:** 23 **DRAINAGE:**Evans Creek

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TYPE OF LAND USE CHANGE: Construction of multiple single family residences

PRE-EXISTING SITE CONDITIONS: 100% upland forest (mixed coniferous/deciduous)

CURRENT ADJACENT LAND USE: 70% single family residential, 30% native vegetation (40 year old second growth)

BUFFER REQUIREMENTS: 50 feet

BUFFER DIMENSIONS: Various, 5 to 50 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: There are moderate to level slopes. The species and community complexity are moderate to high. The 50-foot buffer has been maintained for most of the length around both wetlands. There are a few places where it disappears; one is along a road that accesses the wetland where it is simply a paved surface. There is debris along the lot edges that abut the wetland.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 2 wetlands; Evans Creek 28, 29; both are likely to be Category 2 wetlands. Runoff= point and non-point source inputs of road runoff and fertilizer laden water. There are physical disturbances to certain access points in the wetland, wildlife common, especially birds, and many small mammal indicators as well as amphibians. Habitat potential high= snags, shrubs for cover, food species and vegetation complexity. Vegetation= Tsughete, Thujplic, Acercirc, Sambrace, Rubuspec, Oemlcera, Cornstol, Spirdoug Polymuni, Urtidioe.

CRITICAL COMPONENTS OF FUNCTIONING: The functions of biofiltration and nutrient uptake occur in the R/D ponds and grass-lined swales that are located prior to discharge to the wetland and buffer zone. Habitat value overall is high although in a few places the buffer breaks down and is very small.

WERE THE BUFFER GOALS MET? Yes, and they appear to have held up better than most over time, and perform better than the goals stated they needed to.

BUFFER SITE #12 LOCATION: E 212 Ave Se and SE 32nd St., King County
STR: 9/24N/6E **THOMAS BROS. PAGE:** 24 **DRAINAGE:** East Lake Sammamish

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TYPE OF LAND USE CHANGE: Construction of single family residential units

PRE-EXISTING SITE CONDITIONS: 80% forested upland, 20% agriculture fields

CURRENT ADJACENT LAND USE: 70% single family residences, 30% native vegetation

BUFFER REQUIREMENTS: 25 feet

BUFFER DIMENSIONS: various, 0 to 50 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1983

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The buffer has been reduced and fences established along the back of all lots examined. The buffer was incorporated within the fenced lots. Most (90%) of the buffer areas have been altered over the time this project has been in. The attitude of the owners interviewed is that it is their property to do with what they want. There was very little dumping of yard waste.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 54 acres. King County inventoried as wetland #ELS 30. Possibly Category 1 wetland. 60% PEM (Typhlati Phalarun), 30% PSS (Rubudisc, spirdoug), and 10% BOG. Bog portion looks like it is being encroached by Typha and spirea. There are minimal inputs of point and non-point stormwater. There is fertilizer input from some of the lots near the bog and PEM zone. Siltation is high in some areas. Wildlife use high for birds, medium to high for mammals, and medium (potential) for amphibians. There are many snags and much brush vegetation for cover. There are food species present, vegetation complexity overall high but low in some areas. Also, edges at access points are solid Himalayan blackberry. Vegetation= Alnurubr, Thujplic, Tsughete,

CRITICAL COMPONENTS OF FUNCTIONING: There is no prevention of stormwater input which is causing degradation of bog and an increase in size of Typha/Phalaris PEM zone. Most of the buffer acts as a physical barrier, noise reduction is achieved from most of the development, visible screening good, high habitat value in some places for upland habitat.

WERE THE BUFFER GOALS MET? Yes, for physical and visible barrier, but not for stormwater input.

BUFFER SITE #13 LOCATION: Issaquah Pine Lake Rd, King County
STR: THOMAS BROS. PAGE: 30 DRAINAGE: East Lake Sammamish

TYPE OF LAND USE CHANGE: Construction of many single family residential units.

PRE-EXISTING SITE CONDITIONS: Open space, agricultural.

CURRENT ADJACENT LAND USE: 85% single family residential (with 50% pavement buffer, and 35% houses adjacent buffer grass) and 15% native vegetation.

BUFFER REQUIREMENTS: 100-foot consisting of grassy swales.

BUFFER DIMENSIONS: Various, 0 to 35 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1986

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The buffer has landscaping debris deposited and the species complexity and community complexity are both low. Much of the buffer consists of mowed lawn combined with a paved portion that abuts to the residential lots. The wildlife value is low but there are still birds and small mammals. There are signs of domestic animals present. There are a few snags and brush for cover present, and there are food species present. The buffer was installed but is currently being mowed along with the landscaping so that the shrubs are cut off.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 90% POW, 5% PEM, 5% PSS. 1.5 acres compensation, and four acres original wetland. Possible Category 2 wetland. There is debris deposited into the wetland, mostly as a result of landscaping activity. Runoff= point and non-point source including heavy fertilizer inputs. There is a small amount of siltation currently present although during construction this was a problem. Bird use is high and small mammal use is moderate to low. There are no snags or brush in the wetland, but food species are present and vegetation complexity is low to moderate. Vegetation= Thujplic, Alnurubu, Tsughete, Pyrufusc, Cornstol, Salispp, Rubuspec, Loniinvo, Oemlcera, Sambrace, Typhlati, Junceffu, Scirmicr, Phalarun, Veroscut, Carespp, Oenasarm, Lysiamer.

CRITICAL COMPONENTS OF FUNCTIONING: The functions of the buffer are limited. There is little to no biofiltration or nutrient uptake functions present. In fact, the presence of lawns increase the rate of fertilizer input to the wetland. Habitat diversity is low and there is no protection from intrusion. The edge of the open water zone is too steep for a good emergent community to develop.

WERE THE BUFFER GOALS MET? No, the vegetation for the buffer was planted but is being subsequently mowed for viewing purposes. The goals could be achieved and if the mowing is discontinued it will perhaps function in the future if replanted, but it is not currently functioning. There is no monitoring and no enforcement of the buffer requirements set with the plat.

BUFFER SITE #14 LOCATION: E. Lk. Sammamish Prkw SE and SE 40th and 204 Ave SE, King County
STR: 17/24N/6E THOMAS BROS. PAGE 29 DRAINAGE: East Lake Sammamish

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TYPE OF LAND USE CHANGE: Construction of multiple units of single family residential

PRE-EXISTING SITE CONDITIONS: An old farm site. Grass pasture, blackberries, orchard and a small area with hemlock, cedar forest near the current wetland.

CURRENT ADJACENT LAND USE: 100% single family residential

BUFFER REQUIREMENTS: 15 feet from top of stream bank and 25 feet from the centerline of the stream or swale

BUFFER DIMENSIONS: Various, 0 to 25 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1986

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The NGPE is outside the lots, but there is no buffer on most of the wetland proper. Where it exists, it is so narrow that it functions only as a visual screen. There is yard waste in the wetland off the back of lots one to seven; animal scat and physical disturbance from humans. Runoff enters the wetland directly from the site. There are a few snags and brush for cover present, and there are food species present. Physical damage has resulted in the buffer that does exist as a result of human intrusion.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 95% PFO, 5% PSS. 1.5 acre wetland; likely a Category 3 wetland. Runoff= point and non-point source including fertilizer inputs. Physical damage has occurred in wetland as a result of human paths that cross the wetland. It is a long-linear wetland and is easily impacted from either side. Bird life is present in large numbers, but diversity is low. The wetland is an expanded riparian corridor. Vegetation= Alnu rubu, Thujplic, Tsughete, Poputric, Ssali sitc, ZRubuspec, Rubudisc, Rubulasi, Spirdoug, Oenasarm, Lysiamer, Athyfeli, Phalarun

CRITICAL COMPONENTS OF FUNCTIONING: The buffer is basically not functioning because it is not present for most of the length of the wetland. It is acting as a visual barrier only in the few areas where there is a little bit of vegetation left.

WERE THE BUFFER GOALS MET? No, because there was no buffer installed and there was a 15 to 25-foot requirement.

BUFFER SITE #15 **LOCATION:** SE Duthie Hill Rd. and 260-268 Ave., King County
STR: 12/24/6E THOMAS BROS. PAGE 24 DRAINAGE: Patterson Creek

TYPE OF LAND USE CHANGE: Construction of many units of single family residential

PRE-EXISTING SITE CONDITIONS: Forested young second growth, area logged in 1974

CURRENT ADJACENT LAND USE: 85% residential single family units, 15% native vegetation young second growth

BUFFER REQUIREMENTS: 50-foot buffer, monitoring central wetland

BUFFER DIMENSIONS: Various, 0 to 50 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1985

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: Slope 1:4; the vegetation species complexity is low to moderate, and the community complexity is low (where the lawns have taken over the buffer). Stormwater enters the wetland. Runoff flows through culvert in the buffer to the wetland so the buffer does not act as biofilter or nutrient uptake. There are a few birds in the forested area, and there is a small amount of brush for cover in the shrub area.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 15% PEM, 65% PSS, and 20% PFO. 10+ acres in size; possible Category 2 wetland. The permit allowed stormwater to enter wetland. There is some erosion. Runoff= point and non-point source so that fertilizer rich water enters the wetland. Physical disturbance is high to wetland because of the lack of buffer. Wildlife is high for birds, although species diversity is low, and a few small mammals. There are prey species in the wetland. There are a few snags and brush cover is good for habitat. Vegetation= Alnurubu, Acermacr, Acercirc, Tsughete, Thujpllic, Sambrace, Rubuspec,Rubudisc, Rubulasi, Oemlcera, Cornstol, Spirdoug, Carespp, Phalarun, Ranurepe, Oenasarm, Junceffu, Scirmicr.

CRITICAL COMPONENTS OF FUNCTIONING: Buffer is missing or is now lawn so biofiltration and nutrient uptake as well as physical barrier protection are all limited. Habitat diversity is low so wildlife potential is also low. Flood storage is being performed by the wetland so the buffer does not need to provide this.

WERE THE BUFFER GOALS MET? Initially yes, but over time the buffers that were incorporated into the lots have disappeared into more lawn space. Wildlife, water retention, and open space are in natural condition. Monitoring should have been done so all the changes could be documented. Now, a fence should be put up as a barrier, and a dense shrub layer planted to prevent further invasion into the wetland.

BUFFER SITE #16 LOCATION: East side of SR 203 and NE 24-28th St., King County
STR: 21/25N/7E **THOMAS BROS. PAGE** 72 **DRAINAGE:** Snoqualmie River

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TYPE OF LAND USE CHANGE: Construction of single family residences, low density

PRE-EXISTING SITE CONDITIONS: Pasture land and some young second growth forest

CURRENT ADJACENT LAND USE: Residential 65%, native growth 35%

BUFFER REQUIREMENTS: 25 feet in areas away from the Creek, and 100 feet adjacent to the Creek.

BUFFER DIMENSIONS: Various, 0 to 130 feet. (25% along SR 203 missing)

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1985

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The buffer is route 203 for a section which means there is no buffer and the road runoff flows directly into the wetland. The buffer has been mowed extensively, excavated/or bulldozed in some areas, and trampled in others. The portion that backs onto lots appears to be in the best shape. Only one instance of yard waste was seen. The areas with thick buffer are diverse and healthy and show lots of wildlife, especially birds.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 15+ acres, 70% PEM, 10% PSS, 15% PFO; probably a Category 2 wetland. Banks of the Creek are disturbed physically and chemically (oil residue). Banks of the creek have been highly disturbed by shoes, tires from OTV's. Erosion and sedimentation is occurring in the creek. Vegetation has been trampled in many places (worse than in 1988). Water was clear in 1985, but is now somewhat turbid in places. The stream is salmonid habitat (home owner). Vegetation= Typhlati, Phalarun, Junceffu, Juncensi, Juncaccu, Careobnu, Scirmicr, Oenasarm, Spirdoug, Poputric, Thujplic, Alnu Rubu, Sali Scou, Sali Sitch, Rubuspec, Rubudisc, Oemlcera, Loniinvo, Pyrufusc.

CRITICAL COMPONENTS OF FUNCTIONING: Biofiltration occurs for half of the buffer at least along areas where buffer is forested and/or is greater than 50 feet wide (see from presence of invasive species and lack of sediment). Nutrient uptake occurs in areas off back side of lots, but not along SR203. Habitat diversity in forested buffer areas that are thick (greater than 25 feet), but not very diverse off areas that are typha, Phalaris PEM type wetlands that are adjacent to SR203. The buffer is also not aesthetic along SR203. Vegetation community is lacking in the buffers along the road, and in areas north of the PEM pasture. It is good in forested area. Physical disturbance is high in many places within the wetland. The buffer is therefore not functioning in preventing physical disturbance.

WERE THE BUFFER GOALS MET? For the most part. The worst problem is the lack of buffer along SR203 where the worst source of point and non-point stormwater inputs. There is also a lot of physical disruption around the wetland and buffer zone. This was also a problem in 1988 during the last buffer analysis.

BUFFER SITE #17 LOCATION: Kent Kangley Road and Witte Rd. SE, King County
STR: 33/22N/6E **THOMAS BROS. PAGE:** 57, 58 **DRAINAGE:** Jenkins Creek

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TYPE OF LAND USE CHANGE: Construction of a golf course to the south and a club house on the hill above the wetland to the east. Plus several multifamily residential units to the east.

PRE-EXISTING SITE CONDITIONS: Uphill was a forest, to the south was forest, and more of a native vegetation zone (now golf course)

CURRENT ADJACENT LAND USE: 10% Golf course, 25% single family residential, 35% multifamily residential, and 10 % agricultural.

BUFFER REQUIREMENTS: 50 feet

BUFFER DIMENSIONS: Various, 0 to 150 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1983 to 1988, with most of the work occurring in 1988

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: 50% is 25 to 150-foot forest buffer, 30% is 0 to 50-foot shrub buffer, and 20% is 0 to 50-foot landscaping grasses. Intrusions consist of physical invasion including erosion and a minor amount of siltation and chemical including point and non-point runoff. The wildlife habitat potential is good. There are many birds, small mammals, and amphibians. The vegetation complexity for both species and community in the intact areas is high.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 15% PEM (carex, grass), 20% PSS (willow, spirea) and 65% PFO (cedar hemlock); 28 acres; possible Category 2 wetland. Runoff= point and non-point source pollution including heavy metals loadings, oil and grease from road runoff and siltation. Wildlife use is high for birds, small mammals, and amphibians and the prey species numbers is low although is increasing with the new lots above the wetland. Habitat features are excellent for all, snags, brush/cover, food species, and vegetation complexity. Vegetation= Tsughete, Thujplic, Alnurubr, Poputric, Oemlcera, Rubuspec, Loniinvo, Smabrace, Menzfere, Oplohorr, Salilasi, Saliscou, Spridoug, Phalarun, Carespp, Scircype, Ranurepe, Athyfeli, Polymuni, Glycgran.

CRITICAL COMPONENTS OF FUNCTIONING: The buffer functions for upland wildlife habitat, as a protective barrier to physical intrusion. The wetland is so large that any deficient buffer areas are still buffered by the first few feet of the wetland itself. There is no buffer along the road, and in fact the road crews bulldoze the wetland edge every year causing physical damage to the wetland. There is road runoff that has been shown to result in high heavy metals loadings in the vegetation. Biofiltration and sedimentation is occurring in the R/D pond built adjacent to the buffer along the NE edge of the wetland. In effect, loss of buffer along the periphery has resulted in loss of 50 feet of wetland around the perimeter.

WERE THE BUFFER GOALS MET? Various. The permittee was required to renew the vegetation along the logging road along the eastern border of the wetland and it has never been done. Loss of functions along the south where the golf greens maintenance abuts the wetland in places so mowing and fertilizer input is high to the wetland. The road along the eastern border has cut into the buffer and so is now directly adjacent to the wetland in places allowing runoff and physical intrusion into the wetland. Goals were attainable but were not all attained because of human activities.

BUFFER SITE #18 LOCATION: SW Auburn Black Diamond Rd, and SE 324 St., King County
STR: 13/21N/5E **THOMAS BROS. PAGE:** **DRAINAGE:** Soos Creek

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TYPE OF LAND USE CHANGE: Single family residences, multiple units

PRE-EXISTING SITE CONDITIONS: Forested, scrub-shrub wetland with surrounding medium age second growth forest, few residences.

CURRENT ADJACENT LAND USE: 85% single family residences, 15% native vegetation.

BUFFER REQUIREMENTS: 25 feet, 50-foot building setback

BUFFER DIMENSIONS: Various, 0 to 35 feet

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: There are areas cleared of vegetation to the north. The wetland to the east goes off the property and there is no buffer there. There is a lot of dumping (tires, refuse). Yard waste dumping is the worst on this site of any studied; huge mounds of grass and wood clippings. There is spraying of herbicides along the road directly adjacent to the wetland. There has also been some clearing along the road. Physical damage is perhaps the greatest threat.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: Wetland is 3 acres: Possibly a Category 2 or 3 wetland. 15% PEM (Phalarun,Juncensi), 65% PSS (Salispp), 20% PFO (Alnurubr). The wetland is also located off the plat and is receiving most of the disturbance from there. There is also horse activity in the wetland which is affecting water quality. There is obvious siltation input as well as turbidity mostly due to fecal material and trampling from horses. There are a few snags and shrub cover (willows) is extensive. The density of bird life is great, but not sure about diversity. There are a few snags, and brush cover is high. The wetland is mostly emergent reed canary grass meadow, but does have a little PSS and PFO. The overall wetland is diverse. Vegetation= Alnu rubr, Sali lasi, Salisitc, Spirdoug, Symphalba, Oemlcera, Athyfeli, Urtidioe, Phalarun, Junceffu, Carespp.

CRITICAL COMPONENTS OF FUNCTIONING: Biofiltration of road runoff and lot runoff is not happening to the extent it should. Pesticides used to kill a section of the buffer are also entering the wetland. Habitat diversity is minimal because of the narrow width of the buffer. There is no buffer along the road to stop noise or afford an aesthetically pleasing view of the wetland.

WERE THE BUFFER GOALS MET? Yes, but they were not appropriate. The wetland edge was mistakenly marked and so the buffer was not as large as was thought. The site adjacent has no buffer at all and there are some problems with human and horse intrusion into the wetland.

BUFFER SITE #19 **LOCATION:** SE Auburn Black Diamond Rd., and SE 325 Pl.
King County
STR: 18/21N/6E THOMAS BROS. PAGE: DRAINAGE Soos Creek

TYPE OF LAND USE CHANGE: Construction of single family residential

PRE-EXISTING SITE CONDITIONS: Auburn Black diamond rd, Covington Creek (class 1 stream), forested (20%) and pasture (25%).

CURRENT ADJACENT LAND USE: 50% residential units, 20% native vegetation (mixed coniferous/deciduous and shrubs), 30% Auburn Black Diamond rd and Covington Creek.

BUFFER REQUIREMENTS: 50 foot plus 15-foot building setback, home owners to form an association to monitor the wetland and buffer.

BUFFER DIMENSIONS: Variable, 25 to 200

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? As best as can be determined

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: There is some road gravel that is now running a path within 25 feet of wetland CC19. Some of buffer is forested. Vegetation= PSEUMENZ, ACERCIRC, ALNURUBR, ROSA SPP., SALISCOU,SAMBRACE, RUBUPARV, RUBUSPEC, GAULSHAL, RUBUURSI, DICEFORM, POLYMUNI, PTERAQUI, URTIDIOE.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: Covington Creek 19 CLASS 2, 10+ acres. Covington Creek is a Class 1 stream. Runoff= point and non-point. Signs of domestic animals in wetland, so no nesting birds or small mammals. Vegetation= RUBUSPEC, SPIRDOUG, ALNURUBR, POPUTRIC, THUJPLIC, TSUGHETE, RUBUDISC, SALILASI

CRITICAL COMPONENTS OF FUNCTIONING: Wildlife habitat, physical protection from owners, noise block from Auburn Black Diamond Rd., drainage block from source and non-point pollution, fertilizer from houses, flood storage, habitat diversity

WERE THE BUFFER GOALS MET? Mostly, the road through the buffer was not addressed in the requirements. One owner heard nothing about a home owner's booklet or discussions to preserve the buffers and wetlands.

BUFFER SITE #20 **LOCATION:** 124-128 Ave SE and SE 78-89th St., King County
STR: 28,33/24N/5E THOMAS BROS. PAGE 28 DRAINAGE:May Creek

TYPE OF LAND USE CHANGE: Multiple units of high density single family residences

PRE-EXISTING SITE CONDITIONS: 30+ year old second growth forest,

CURRENT ADJACENT LAND USE: 85% high density, single family residents (65% lots, 15% paved, grassy sidewalks), 15% young second growth native vegetation.

BUFFER REQUIREMENTS: 25 feet

BUFFER DIMENSIONS: Various, 0 to 25

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987 to 1989

IMPLEMENTED AS PLANNED? Yes

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: The buffers were established at 25 feet in 1987, but have been lost to the back of lots, or for sidewalk area since then. It even looks like a sidewalk was being used for the buffer in a few places. There is lots of yard waste along the buffer/wetland edge.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: 10% PEM (mostly reed canary grass), 80% PSS (spirea, some willow), and 10% PFO (alder cedar); probably Category 3 wetland. The wetlands on the site are small Category 3 type, mostly PSS, low diversity with lots of invasive species. Runoff= point and non-point source with definite nutrient loadings, and possible road runoff. Wildlife potential is low for birds (crows and robins) because of lack of habitat. There are a few snags and some brush areas that are suitable habitat, but the wetlands are so small that not many creatures can survive. Vegetation= Thujplic, Tsughete, Alnurubr Poputric, Acercirc, Rhampurs, Salix spp, Spirdoug, Rubuspec, Loniinvo, Junceffu, Phalarun, and Ranurepe.

CRITICAL COMPONENTS OF FUNCTIONING: The encroachment into the buffer on so much of the site means there is very little left for buffering functions of any kind. A 25-foot strip does not leave much for noise control let alone cover, food, biofiltration, nutrient uptake. Invasive species of blackberry are taking over these areas.

WERE THE BUFFER GOALS MET? Perhaps the first year, but not currently.

BUFFER SITE #21 LOCATION: 116 Ave SE 76 St., King County
STR: 28/24N/5E THOMAS BROS. PAGE: 28 DRAINAGE: May Creek

TYPE OF LAND USE CHANGE: Construction of multiple single family residences

PRE-EXISTING SITE CONDITIONS: Forested, 30+ years old second growth, pasture, and low density residential.

CURRENT ADJACENT LAND USE: 35% single family residential, 15% agricultural fields, 50% native vegetation (30+ years second growth).

BUFFER REQUIREMENTS: Variable. 50 feet on wetland (Class 2, King Co.), 200 feet on creek (class 5)

BUFFER DIMENSIONS: Various, 0 to 150, and within the 25-foot floodplain

WHEN WAS THE LAND USE CHANGE IMPLEMENTED? 1987

IMPLEMENTED AS PLANNED? As far as can be determined

BUFFER: CURRENT CONDITIONS AND FUNCTIONING: Biofiltration, nutrient uptake on lots adjacent to wetland, habitat diversity limited because they cut down much of the vegetation and replanted with ornamental shrubs, flood storage since uphill from the stream, and protection from intrusion where buffer is intact.

WETLAND: CURRENT CONDITIONS AND FUNCTIONING: Wetland is medium size greater than 1 < 10 acres, Class 2 (King Co.); forested and scrub/shrub, adjacent to Class 5 stream. It functions as flood storage from stream, diverse habitat availability. Runoff= point and non-point. Fertilizer inputs affecting wetland in areas adjacent to two lots where invasive species are present (JUNCEFFEU, and PHALARUN). There is no buffer by road near entrance so wetland edge is highly disturbed. Cement truck washout into wetland and ranurepe, and junc effu only there. Vegetation= THUJPLIC, ALNURUBR, POPUTRIC, RHAMPURS, RUBUDISC, RUBULASI, OEMLCERA, PRUNEMAR, LYSIAMER, OENASARM, RANUREPE, MAIADILA, STACCOOL, SCIRMICR, CARESPP, PHALARUN, JUNCEFFU, JUNCENSI.

CRITICAL COMPONENTS OF FUNCTIONING: There is limited biofiltration for nutrients and sediment. (stream murky in places where buffer is missing), habitat diversity, visual screen, flood storage actually quite good for stream.

WERE THE BUFFER GOALS MET? Some yes, some no. Did not ascribe buffer as NGPE and residents who abut wetland and stream have included the buffer into their lots and mowed much of the buffer. Also, there was no buffer left on wetland that abuts the entrance road and there is extreme disturbance to wetland there. Buffer is functioning where it is intact, but disturbance is occurring where there is no buffer.

The following sources of information were utilized in the literature search:

A. Computer Search Programs.

AFSA; Enviroline; Water Resources; NTIS; Pollution; Life Sciences; AGRICOLA; and Biosis.

B. On-Line Library Collections.

University of Washington libraries: Natural Sciences; Fisheries; Forestry; Engineering; and Architecture.

C. Existing Bibliographies.

King County Sensitive Areas Ordinance Bibliography (1990); "Wetland Buffers: An Annotated Bibliography (Castelle et al., 1991a); "Wetland Compensatory Mitigation Replacement Ratios: An Annotated Bibliography (Castelle et al., 1991b); "Wetlands Protection" (USEPA Bibliographic Series, 1988).

D. Research Centers.

Natural Resources Research Institute (Duluth, MN); Center for Wetlands (University of Florida, Gainesville); School for Oceanography (Louisiana State University, Baton Rouge); College of Forest Resources (University of Washington, Seattle); College of Forestry (Oregon State University, Corvallis).

E. Washington State Agencies.

Department of Ecology; Puget Sound Water Quality Authority; Department of Fisheries; Department of Transportation.

F. Federal Agencies.

Federal Highway Administration; U.S. Fish and Wildlife Service; U.S. Soil Conservation Service; U.S. Forest Service; Environmental Protection Agency; and the U.S. Army Corps of Engineers.

G. State Agencies.

California Department of Fish and Game; Oregon Department of Transportation; Idaho Transportation Department; Maryland Department of Natural Resources; Delaware Department of Wetlands & Aquatic Protection.

H. County Planning Departments.

King; Kitsap; Pierce; San Juan; Snohomish; Thurston; Whatcom.

I. City Planning Departments.

Auburn; Bellevue; Bellingham; Des Moines; Everett; Federal Way; Kirkland; Redmond; Renton; Tukwila.

J. Professional Organizations.

Association of State Wetland Managers; Environmental Law Institute Society of Wetland Scientists.

K. Environmental Organizations.

Audubon Society; Conservation Foundation; Geraldine R. Dodge Foundation.

L. Individuals Contacted.

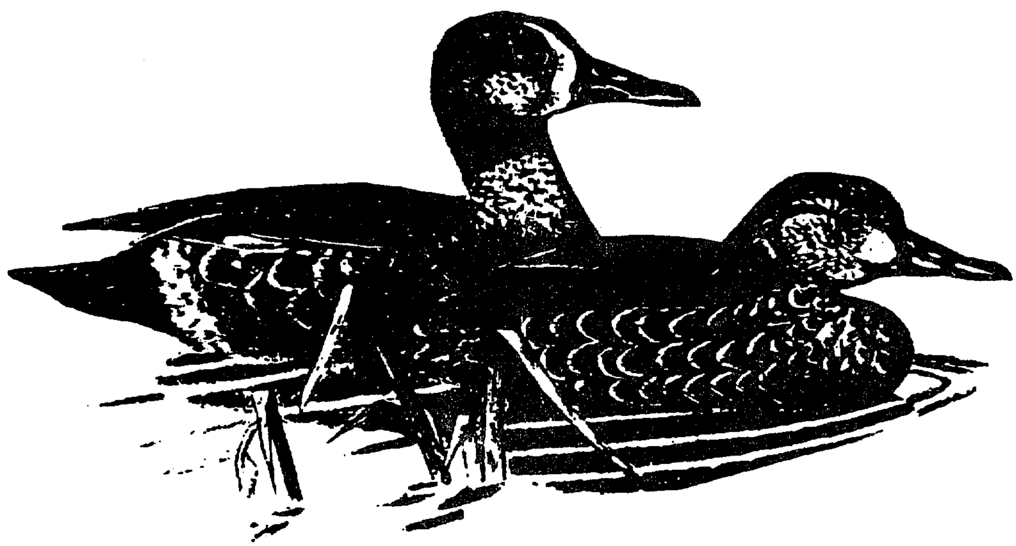
J. Hoffmann, URS Consultants, Cleveland, Ohio; G. Rollins, California Dept. of Fish and Game; P. Dykman, Oregon Dept. of Transportation; D. Evans, City of Eugene Public Works; R.B. Tiedemann, Idaho Transportation Dept.

CURT SMITCH
Director

STATE OF WASHINGTON
DEPARTMENT OF WILDLIFE
600 Capitol Way North • Olympia, Washington 98501-1091 • (206) 753-5700

FINAL DRAFT:
FEBRUARY 12, 1992

BUFFER NEEDS OF WETLAND WILDLIFE



HABITAT MANAGEMENT DIVISION

The Fragment Connection by William Stolzenburg, Nature Conservancy, July/August 1991:

"Fragmentation entails a biological fallout more complicated than an arithmetic reduction of living open space might intuitively suggest. Ecologists have lately begun to see more clearly what happens when, say, a big forest suddenly becomes a small forest squeezed by development. From the isolated remnant disappear the wide roamers--the bears, big cats and wolves. The same goes for the deep forest specialists, types like the hooded warbler, the goshawk and the marten. Flooding in from the outside are the generalists, the common species of the edge--the starlings and cowbirds, the opossums and raccoons. Like an onion peeled by the layers, there comes a point when the core becomes nothing but the edge, a place where the generalists rule." Page 20.

"According to population theory, the fewer the individuals, the more potentially devastating the purely random forces of nature. A roll of the demographic dice can leave a small population with too many old, too few females, too little genetic variability--too little internal rebound to survive. Natural catastrophes, like fires, storms, droughts and disease--blows that might dent a big population--can crush a small one." Page. 20.

WETLANDS - PROVIDE FOOD, WATER, SHELTER FOR FISH AND WILDLIFE

Wetlands and their buffers are essential for wildlife. The complex interface of land and water is used to meet life needs by 85% of terrestrial wildlife species in the State (Brown, 1985; Thomas, 1979).

One value provided by wetlands is production and maintenance of the public's fish and wildlife resources. If there is to be no-net-loss of wetland area and function, it is essential that wetland protection measures and buffers be planned to protect fish and wildlife.

WETLAND SYSTEMS = WETLANDS + ADJACENT UPLANDS

Wetlands and the uplands adjacent to them form a physical, hydrologic, chemical and biologic system. Native fish and wildlife populations have evolved with this system and take advantage of interactions.

Large numbers of wetland dependent wildlife need not only the wetland but also the adjacent upland to meet essential life needs: food, water, shelter from climatic extremes and predators, structure and cover for reproduction and rearing of young. For example, waterfowl feed primarily in wetlands but most species nest on dry ground where nests will not be flooded. In the Columbia Basin, heavy grazing next to wetlands removed buffer vegetation and reduced waterfowl production by 50% (Foster et al. 1984). A wetland may be preserved but if the waterfowl nesting habitat in the adjacent upland is lost, a component of the wetland's function is lost.

DISTURBANCE AND LOSS OF WILDLIFE FUNCTION

A person approaching heron or a flock of waterfowl can agitate and flush them even at distances greater than 200 feet. In 1976-7, Department of Wildlife found migratory bird use increased 30-50 fold on three Columbia Basin wetlands where parking lots and access were relocated to areas 0.25 to 0.5 mile from the wetlands (Foster et al. 1984). Conversion of farm lands to office park along North Creek in King and Snohomish counties, significantly reduced the function of the areas wetlands for migratory waterfowl although the wetlands remain.

Many of the wet pasture areas that provide waterfowl feeding are frequently not scored high in wetland rating systems because of low diversity of plant life. If there is to be no-net-loss of wetland wildlife function, even these will need sufficient buffers.

HABITAT FOR MOST SPECIES = PLANT STRUCTURE OVER DISTANCE

Animals evolved with different plant communities and hydrology in and around wetlands. They depend upon plant communities and their associated physical structures both inside and outside the wetland. To retain full complements of wetland dependent wildlife, the plant structure in adjacent uplands needs to be retained for sizable distances from the wetland edge.

Wetland dependent wildlife such as salamander, waterfowl, beaver, and mink use the adjacent uplands to meet essential life needs. They are dependent on both the wetland and the adjacent uplands. The buffer zones are areas where animals have needed separation and interspersion to reduce competition and maintain populations. The more narrow the buffer left around a wetland when land use changes, the more susceptible the wetland becomes to loss of habitat function and productivity. Remaining wetland wildlife are more concentrated and more vulnerable to disease and predation.

WETLAND BUFFERS - ALSO ESSENTIAL FOR WETLAND-RELATED WILDLIFE

Natural vegetation next to wetlands moderates extreme environmental conditions. Plant structures provide microclimates that keep water and surface temperature cooler in summer and warmer in winter than surrounding areas.

Lush and divergent vegetation in wetland buffers provides food and cover for many species ranging from large mammals such as deer and elk, to small ones such as voles and shrews. These areas are used for rearing of young. They receive heavy use by animals that concentrate near wetlands but are not necessarily wetland dependent. In Grant County loss of wetland buffers and the cover they provide significantly reduced pheasant populations to 20% previous levels.

Wetland buffers provide nutrients and cover for aquatic systems and their organisms. Large organic debris has been shown to be essential for native fish populations. It provides for pool development and fish hiding cover. Also important is small organic debris, the leaf litter from trees and shrubs. Ninety percent of the biological energy in some aquatic systems comes from leaf litter. Buffers help to maintain existing fish and aquatic invertebrate levels. They also maintain water quality by filtering sediments and pollutants.

WETLANDS WITH OPEN WATER COMPONENTS - NEED LARGER BUFFERS

Brown (1985) reports that 50 vertebrate species use the water-shrub edge for primary breeding or feeding; 46 use the water-forest edge, 98 use the riparian zone of herbaceous wetland, and 85 use ponds. Medin and Clary (1990-1991) found more than 3 times the bird biomass and species richness and mammal density and biomass in beaver ponds wetland complex than in adjacent riparian areas. USFWS reports show that wetland dependent species, dependent in part on open water, needed large buffers.

EVEN SMALL WETLANDS NEED BUFFERS

Size is not the main determinant wetland value to wildlife and need for protection. A Columbia basin study (Foster et al. 1984) showed that there was an inverse relationship between wetland size and waterfowl production. Highest density of ducklings were observed on wetlands of five acres or less in size and were particularly abundant on wetlands from 0.1 to 1.0 acre. In this study 68% of nests were within 100 feet of water and all but six of the rest were within 300' of the water.

Many amphibians achieve their highest densities in small wetlands (McAllister and Leonard, pers. observation). Long-toed salamander is one example. It cannot survive in the presence of healthy fish populations. It breeds in small temporary ponds. In small headwater streams of the Pacific Northwest, amphibians are the dominant vertebrates. Their numbers and biomass in these small streams are often greater than that of coldwater fishes in their optimal habitat (Bury et al. 1991).

Small wetlands are frequently very sensitive to impacts. For example, when stream gradient is greater than 4%, most beaver pond wetlands are less than 2 acres in size. They are very sensitive to silting and increased stream flows from logging in a watershed. They suffer greater losses from "blowouts" in high flow events. They may lose their soils and all vegetation in such an event.

DRY CLIMATES CONCENTRATE WILDLIFE USE

Influence of the water table on the landscape and vegetation is often reduced on the eastside of the state with more abrupt wetland-upland edges. Wildlife use tends to be concentrated closer to water in drier climates. Hall (1970) showed more narrow beaver use on streams in eastern California than had been reported in the literature (100' vs. 328'). Mudd (1975) showed minimum riparian area for maximum pheasant and deer use to be 75 feet in one eastern Washington study.

SUMMARY

To retain wetland dependent wildlife in important wildlife areas, buffers need to retain plant structure for a minimum of 200-300 feet beyond the wetland. This is especially the case where open water is a component of the wetland or where the wetland has heavy use by migratory birds or provides feeding for heron. The size needed would depend upon disturbance from adjacent land use and resources involved.

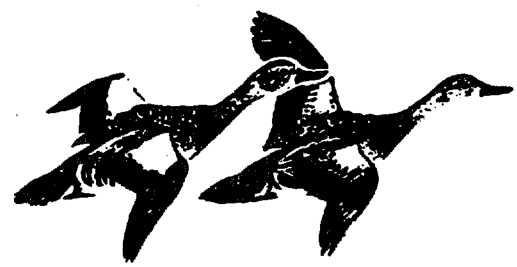
In western Washington wetlands with important wildlife functions should have 300' upland buffers for high impact (urban) land uses and 200' upland buffers for low impact (rural) land uses. In eastern Washington wetlands with important wildlife functions should have 200' upland buffers for high impact land use and 100' buffers for low impact land uses.

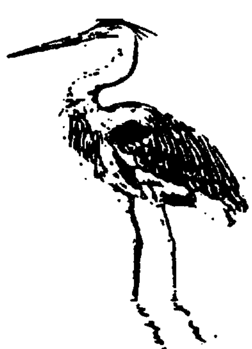
Priority species or especially sensitive animals or wetland systems such as bogs/fens or heritage sites may need even larger buffers wetlands to prevent disturbance or isolation of subpopulations or other loss of wetland function or value. See Attachments 1, 2, and 3 for buffer ranges.

WETLAND DEPENDENT SPECIES USE OF NON FORESTED BUFFERS TO WETLANDS

Wildlife Needs in Herbaceous Vegetation Next To Wetlands:

Blue-winged teal
Literature: Sousa, Patrick J. 1985. USFWS HEP Model. Select grassy vegetation for establishment of nest sites (Bellrose 1976). They need 3 acres of upland for each acre of wetland for breeding. The annual loss of untilled upland nesting cover is a major factor contributing to suppressed duck production, regardless of water conditions (Higgins, 1977). Blue-winged teal nests in North Dakota averaged 840 feet from water (Duebbert and Lokemoen, 1976). Optimum nest cover values are assumed to occur at less than 820 feet from any wetland other than ephemeral wetlands.



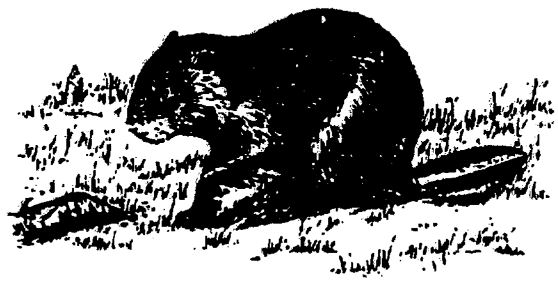


Great Blue Heron
Literature: Short, H. L. and R. J. Cooper, 1985. USFWS HEP Model. Great blue heron tolerate human habitation and activities about 328 feet from a foraging area and occasional, slow moving, vehicular traffic about 164 feet from a foraging area.

WETLAND DEPENDENT SPECIES USE OF NON FORESTED BUFFERS TO WETLANDS (cont.)

Wildlife Needs in Shrub Vegetation Next To Wetlands:

Beaver
Literature: Allen, Arthur W. 1983. USFWS HEP Model. HEP Model models on 600' from wetland edge. Trees and shrubs closest to water are used first (Bradt, 1938). Majority of beaver feed within 328 feet of water. Study in dry environs: 90% beaver feed 100' from water (Hall, 1970).



Belted Kingfisher
Literature: Prose, Bart L. 1985. USFWS HEP Model. Broods use shrub cover along water for concealment (White, 1953. Roosts were 100 to 200 feet from water.

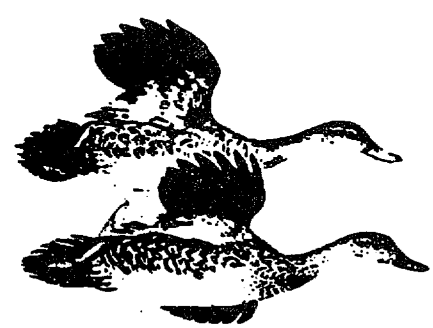
WETLAND DEPENDENT SPECIES USE OF NON FORESTED BUFFERS TO WETLANDS (cont.)

Wildlife Needs in Either Shrub Or Herbaceous Vegetation in Buffers:

Red-winged Blackbird
Literature: Short, Henry L. 1985. USFWS HEP Model. Red-winged blackbirds nest in wetlands. Only foraging sites within 656 feet of wetlands that contain nest sites are assumed useful to blackbirds.

Lesser Scaup
Literature: Allen, Arthur W. 1985. USFWS HEP Model. The majority of lesser scaup nests have been recorded within 33 feet of the water's edge. They have been found up to 1300 feet from water. The most preferred nesting habitat for lesser scaup is assumed to occur when a 164 foot zone surrounding permanently flooded intermittently exposed, and semipermanent wooded wetlands with 30% to 75% canopy cover of herbaceous vegetation. Lesser scaup most frequently are observed on wetlands with at least half of the shoreline bordered by trees and shrubs.

Gadwall
Literature: Sousa, Patrick K., 1985. USFWS HEP Model. The average distance from nest sites to water was less than 150 feet in several studies of gadwalls: Miller and Collins, 1954; Gates, 1962; Vermeer, 1970. But gadwall nests in North Dakota averaged 1150 feet from water, Duebbert and Lokemoen (1976). Gadwalls typically select the tallest, densest, herbaceous or shrubby vegetation available in which to nest.

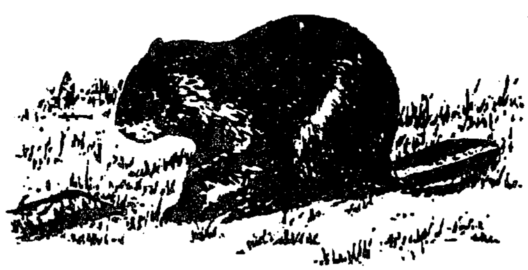


WETLAND DEPENDENT FOREST SPECIES USE OF WETLAND FOREST BUFFERS

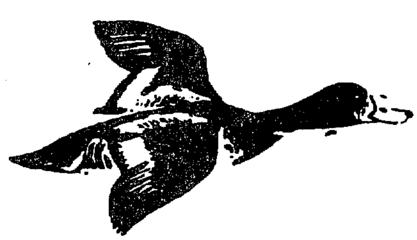
Wood Duck
Literature: Sousa P.J. and A. Farmer. 1983. USFWS HEP model. Limiting features: open water, marsh or shrubs & snags: 14 inch tree minimum but best nest in 24-30 inch dbh. Distance 0-1149 feet from water but 262' average, (Gilmer, 1978). Most nests within 600' of water (Grice and Rogers, 1965).

Mink
Literature: Allen, Arthur W. 1981. USFWS HEP Model. Limiting features: cover surface water. Mink use forest 600' from open water (Melquist, 1981, and Linn and Birks, 1981). Most use is within 328' of wetland edge. Mink cover requirements: 75-100% forested. Den sites in Idaho were placed up to 328' from wetland edge.

Beaver
Literature: Allen, Arthur W. 1983. USFWS HEP Model. Beaver feed up to 600' from wetland edge. Trees and shrubs closest to water are used first (Bradt, 1938). Majority of beaver feed within 328' of water. Study in dry environs: 90% beaver feed 100' from water (Hall, 1970).



Lesser Scaup
Literature: Allen, Arthur W. 1986 USFWS HEP Model. Nest up to 165' from water in herbaceous layer.



WETLAND RELATED SPECIES USE OF FORESTED BUFFERS OF WETLANDS

Pileated Woodpecker
Literature: Schroeder, 1983:
USFWS HEP Model.
Pileated's nesting within
492' of water. Most
nest within 164' of water.

Marten
Literature: Allen, Arthur W.
1982. USFWS HEP Model.
Timber harvest decimates
marten populations (Yeager,
1950). In Wyoming no use of
harvested timber stands for 1
year (Clark and Campbell,
1976). In Maine, no use of
clear-cut for 15 years
(Soutiere, 1979).
WDW Management Recommendations:
no harvest recommended within
200' of riparian (Spencer,
1981).

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Attachment 1: Buffer Size

The question is always asked: How big do buffers need to be and what is the minimum size buffers can go down to? However, the question we need to ask is: What is needed to maintain a healthy wetland habitat system over time so that functions of that wetland are retained in changing rainfall pattern, in drought periods, in high rainfall events, in times of plant and animal diseases? The narrower the vegetated upland adjacent to wetland, the more susceptible wetland wildlife are to stresses and disturbances. Also the narrower this zone is, the more susceptible the area is to loss of habitat function and productivity through natural changes or human induced impacts. The following is a summary of buffer needs of selected species.

Buffer Zone Needs of Fish and Wildlife:

600 feet or larger:
- bald eagle nest, roost, perch, feeding - forest;
- cavity nesting ducks (wood duck, goldeneye, bufflehead, hooded merganser) - forest;
- heron rookery - forest;
- woodland caribou - forest;
- Western pond turtle - forest/nonforest;
- American white pelican nest colonies;
- sandhill crane nest and feeding - forest/nonforest.

450 feet:
- common loon nest sites;
- pileated woodpecker. High use in wetland forest buffer zones.

300-330 feet:
- beaver - forest/shrub;
- dabbling duck nesting (mallard, teal, redhead, etc.) - forest;
- mink - forest/shrub;
- gray wolf-forest;
- distance (disturbance free) to preserve heron feeding in wetland;
- distance from shoreline development to preserve black brant feeding in eelgrass beds.

200 feet:
(height of tallest tree in Western Washington):
- Columbia-white tailed deer in agriculture/forestry environment;
- trout and salmon influence zone (Western Washington)
- Beller's ground beetle - forested/nonforested;
- Hatch's click beetle - forested/nonforested;
- long-horned leaf beetle - forested/nonforested;
- moose in agricultural/forestry environments;
- spotted frog (Western Washington).

165 feet:
- lesser Scaup nesting - forested/nonforested;
- harlequin duck - forested/nonforested.

100 feet:
(potential height of tallest tree in Eastern Washington)
trout and salmon food source, shade and undercut banks;
trout and salmon influence zone (Eastern Washington) and
source of large organic debris - forested;
spotted frog (Eastern, Washington) - forested/nonforested;
Van Dyke's Salamander - forested.

30 feet:
muskrat feeding and denning.

We know from the existing body of scientific literature that many of the wetland dependent species have some critical life needs met in both the aquatic area adjacent to the wetland and upland areas adjacent to the wetland. From these studies we can obtain a picture of the depths of the buffer zone needed. We estimate what functions could be expected to be retained over time with different size buffers. For example:

300 foot buffers forested	-	waterfowl breeding and feeding retained; diversity of mammal habitat including beaver, mink, muskrat, deer if connected via stream corridors or vegetation to other habitats. Much of the habitat for cavity nesting ducks. Diverse bird habitat including raptors, woodpeckers and song birds.
200 foot buffers forested	-	waterfowl breeding but some reduced numbers. Most components but some reduction of mammal populations. Most forest interior species as well as forest edge species on larger systems. Some of the mink and beaver remain. Total complement of large organic debris for salmonid fishes, and amphibians. Minimum size for high level wildlife use in western Washington.
100 foot buffers forested	-	waterfowl nests such as mallard but reduced populations. Salmonid and nonsalmonid fishes but reduced large organic debris in some systems. Diverse song bird populations. Reduced populations of beaver especially on low gradient streams in western Washington. May eliminate mink and marten except in larger forested wetland systems. Minimum size for high level wildlife use in eastern Washington.
50 foot buffers	-	warm water fishes; muskrat and small mammals only mammals represented. Reduced song bird use.

Attachment 2: Priority Species Identified by WDW PHS Program

Buffer requirements listed in Rodrick, E. and R. Milner. 1991 Management Recommendations for Washington's Priority Habitats and Species, Washington Department of Wildlife:

Priority species are wildlife species of concern due to their population status and their sensitivity to habitat alteration.

Bald Eagle - design Management Plan to meet needs:
nest - 1300; roost - 1300-2600; perch - 160-1000'; feeding - 1500'.

Common Loon
nest - 450'

Priority Fish Species - Buffers on streams:	
Cutthroat trout	50-200'
Dolly varden (Bull trout)	50-200'
Mountain sucker	50-200'
Mountain whitefish	50-200'
Pygmy whitefish	50-200'
Rainbow trout and steelhead	50-200'
Dunn's salamander	
Type 4 and 5 stream	25-69'
Great Blue Heron	
colony or rookery	820-981'
Harlequin duck	
nesting streams	165'
Mountain caribou	1300' on lakes and fens >1/4 Acre.
Osprey	
nest	130-660'
water bodies with nest	200' on entire water body.
Yellow billed cuckoo	
riparian areas > 4 acres	300'
Mule Deer	
fawning in riparian	
unforested	600'
forested	tall stands of conifers > 5 acres.
Sandhill crane	
nest	1300'
feeding	2600'
Van Dyke's salamander	90-150' Forested wet talus edge
Western Pond turtle nest	660' around wetlands.

Attachment 3: Use Of Vegetated Wetlands by Fish for Breeding, Feeding, Predator Avoidance, Thermal Protection:

Estuarine Habitats:
Wetland Use

Sources:	Brown (1985)	Simenstad, C.A. et al. 1991. Estuarine Habitat Assessment Protocol. EPA 910/9-91-037
Fishes	Activity	Structure Used
Pacific herring	Breed	Eelgrass
tube snout	Breed/feed	Eelgrass
threespine stickleback	Breed/feed	Marsh
bay pipefish	Feed	Eelgrass
walleye	Feed	
shinner perch	Feed	Eelgrass
striped seaperch	Feed	Eelgrass
saddleback gunnel	Feed	
black rockfish	Feed	
prickly sculpin	Feed	Marsh
buffalo sculpin	Breed/feed	Marsh
Pacific staghorn sculpin	Breed/feed	Eelgrass/marsh
starry flounder		Eelgrass/marsh
chum salmon		Eelgrass/marsh
chinook salmon		Marsh
pink salmon		Marsh
cutthroat trout		Marsh
crescent gunnel		Eelgrass
kelp perch		Eelgrass
lingcod		Eelgrass
penpoint gunnel		Eelgrass
snake prickleback		Eelgrass
northern anchovy		Eelgrass
eulachon		Eelgrass/marsh
surfperches		Eelgrass

Freshwater Habitats (From WDW)

cutthroat trout	feeding	marsh/pond/stream/ wet pasture/forest
coho salmon	feeding	marsh/pond/stream wet pasture/forest
Olympic mudminnow	feeding/breeding	marsh/stream/wet pasture/forest.

From Brown (1985) Appendix 10:

Fishes	Activity	Vegetation/water
shinners	feeding	stream vegetation
tench	feeding/breeding	stream/lake/marsh
bullheads	breeding	pond/lake/stream
threespine stickleback	breeding	pond/lake/stream
black crappie	breeding	pond/lake/stream
yellow perch	breeding/feeding	pond/lake/marsh stream.

From Brown (1985) Appenxix 2:

Loss of adjacent forest vegetation through forest practices are expected to impact 51 species of fish in waters adjacent to the forest practice and 29 species of fish off site.

Buffers Recommendations on Both Sides of Stream for Fish:

Priority Species Management Recommendations	USFWS Habitat Suitability Index	Erman, D.C., J.D. Newbold, K.B. Roby. 1977. Evaluation of Streamside Bufferstrips for Protecting Aquatic Organisms. Cal. Water Resource Center
Provide L.O.D.	Erosion control & undercut banks	Maintain stream sediments and fish food chain.
50-200'	100'	100'

Attachment 4: Western Washington Wetland Associated Species

Condensed from Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington, E. Reade Brown, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, June 1985:

208 terrestrial species dependent upon structure for primary breeding or feeding in wetland systems and type of structure needed:

M - Dependent on only mature forested wetland and/or wetland and upland for a primary breeding or feeding function. Therefore these species are dependent on mature forest structure. Trees in Mature Forest average a minimum of 21 inches dbh.

O - Dependent on only old growth forested wetland and/or upland for a primary breeding or feeding function. Old-growth dependent.

XX - Species has primary breeding and/or feeding listed only in wetland. This demonstrates a strong wetland association.

Priority Species (Underlined are Wetland Associated Priority Species.)

*(State and Federal Concern Species) SE-State Endangered; FT-Federal Threatened; ST-State Threatened; FC2-Federal Candidate Category 2; FC3-Federal Candidate Category 3; FP-Federal Proposed; SC-State Candidate; SM-State Monitor).

	Herbaceous	Shrub	Tree
AMPHIBIANS			
Northwestern salamander	x	x	x
long-toed salamander	x	x	x
Pacific giant salamander			x
Olympic salamander			x
Dunn's salamander *(SC)			x
Western red-backed salamander			xM
rough-skinned newt	x	x	x
western toad	x	x	
Pacific tree frog	x	x	x
tailed-frog			x
red-legged frog	x	x	
Cascades frog	x	x	x
spotted frog *(SC)	x	x	x
REPTILES			
painted turtle	x	x	
western pond turtle *(ST,SC,FC2)	x	x	
western skink	x	x	
sharptail snake *(SM)			x
ring-necked snake *(SM)		x	
gopher snake	x	x	

	Herbaceous	Shrub	Tree
western terrestrial garter snake	x	x	
common garter snake	x	x	
BIRDS			
American bittern	x		
great blue heron *(SM)	XX		XX
green-backed heron *(SM)		XX	
Canada goose	XX		
wood duck	x		xM
green-winged teal	XX		
mallard	XX		
northern pintail	XX		
blue-winged teal	XX		
cinnamon teal	XX		
northern shoveler	XX		
gadwall	XX		
Eurasian wigeon	XX		
American wigeon	XX		
harlequin duck			xM
Barrow's goldeneye			xM
bufflehead			xM
hooded merganser			xM
common merganser			xM
turkey vulture *(S)	x		x
osprey *(SM)			XXO
black-shouldered kite	x		XX
bald eagle *(ST, FT)			x
northern harrier	XX		
sharp-shinned hawk			x
Cooper's hawk			x
red-tailed hawk			x
rough-legged hawk	x		
merlin *(SM)	XX	XX	
American kestrel	x		xM
gyrfalcon *(SM)	XX		
ring-necked pheasant	XX		
ruffed grouse			x
Virginia rail	XX		
sora	XX		
American coot	x		
sandhill crane *(SE)	XX		
killdeer	XX		
spotted sandpiper	XX		
common snipe	XX		
least sandpiper	XX		
marbled murrelet *(SC, FP)			xO
band-tailed pigeon		x	x
mourning dove	x		x
common barn owl	x		

Appendix C

	Herbaceous	Shrub	Tree
western screech owl	x	x	xM
great-horned owl			xM
barred owl *(SM)			xM
long-eared owl	x	x	XX
short-eared owl	XX		
northern saw-whet owl			XXM
common nighthawk	x		
Vaux's swift *(SC)	x	x	xO
chipping sparrow		x	
savannah sparrow	XX		
fox sparrow		x	
song sparrow	x	x	
Lincoln's sparrow	XX	XX	
red-breasted sapsucker			XX
downy woodpecker			x
northern flicker		x	xM
olive-sided flycatcher			x
western wood-pewee		x	xM
willow flycatcher		XX	
Anna's hummingbird	x	x	x
rufous hummingbird	x	x	x
yellow-breasted chat		XX	
western tanager		x	xM
black-headed grosbeak		x	x
lazuli bunting		x	
rufous-sided towhee		x	
hermit warbler			xM
common yellowthroat	XX	XX	
MacGillivray's warbler		XX	XX
Wilson's warbler		x	x
Bohemian waxwing		XX	
cedar waxwing			x
northern shrike	XX	XX	
European starling	x		x
Hutton's vireo		x	
warbling vireo			x
red-eyed vireo			x
yellow warbler		x	
black-throated warbler		x	
Townsend's warbler			xM
black-capped chickadee		x	xM
chestnut-backed chickadee			xM
red-breasted nuthatch			xM
white-breasted nuthatch			xM
Bewick's wren			x
house wren			x
winter wren			xM
marsh wren	XX		
golden-crowned kinglet			xM

	Herbaceous	Shrub	Tree
ruby-crowned kinglet		x	x
western bluebird *(SC)	x	x	
Swainson's thrush			x
hermit thrush			x
American robin	x	x	
varied thrush			xM
water (American) pipet	x		
tree swallow	x	x	xO
violet-green swallow	x	x	xM
northern rough-winged swallow	XX		
cliff swallow	x		
barn swallow	x		
gray jay		x	xM
Steller's jay			x
American crow	x	x	xM
common raven	x	x	xM
Hammond's flycatcher			xM
western flycatcher			xM
black phoebe	XX	XX	
purple martin *(SC)	XX	XX	XXM
golden-crowned sparrow		x	
white-crowned sparrow		x	
dark-eyed junco	x	x	
red-winged blackbird	XX		
yellow-headed blackbird	XX		
Brewer's blackbird	x	XX	
brown-headed cowbird	x	x	x
northern oriole			xM
pine grosbeak			xM
purple finch			x
red crossbill			xO
pine siskin			xM
lesser goldfinch	x	x	
American goldfinch	x	x	
evening grosbeak			x
MAMMALS			
Virginia opossum	x		XX
Pacific water shrew *(SM)			x
dusky shrew			x
Pacific shrew		x	
water shrew			XX
Trowbridge shrew			x
vagrant shrew	x		
shrew mole		x	x
broad-footed mole	x		
coast mole	x	x	
Townsend's mole	x		
pallid bat *(SM)	x		x

Appendix C

	Herbaceous	Shrub	Tree
big brown bat	x	XX	xM
silver-haired bat			xO
hoary bat		x	xM
California myotis			xO
long-eared myotis *(SM)			xO
Keen's myotis *(SM)	x	x	
little brown bat	x	x	xO
fringed myotis	x	x	
long-legged myotis *(SM)		x	x
Yuma myotis	x	x	xM
Townsend's big-eared bat *(SC,FC2)			x
coyote	x	x	
black bear	x	x	
raccoon	x	x	x
wolverine *(SM, FC2)			x
river otter		XX	XX
marten			xM
striped skunk	x	x	
ermine			x
mink	XX	XX	XX
spotted skunk	x	x	
bobcat	x	x	
elk	x	x	x
mule and black-tailed deer	x	x	
Columbian white-tailed deer	x	x	x
mountain beaver		x	
yellow-pine chipmunk		x	
beaver		XX	XX
bushy-tailed woodrat			x
dusky-footed woodrat			x
deer mouse	x	x	
western harvest mouse	x		
southern red-backed vole			xM
gray-tailed vole *(SM)	XX		
long-tailed vole	x	x	
montane vole	x		
creeping vole	x	x	
water vole	XX		
Townsend's vole	x		
northern bog lemming *(SM)	x		
western jumping mouse	x		
Pacific jumping mouse	x	x	
porcupine	x	x	x
nutria	XX		
brush rabbit	x		x
eastern cottontail	x	x	

78 Other species listed in Brown as having primary breeding and/or feeding in wetland systems without reference to structure:

Cope's giant salamander*(SM)	riparian to springs and creeks.
Van Dyke's salamander *(SC)	wet meadows, marshes, bogs, swamps.
ensatina	riparian forest/shrub to sloughs.
bullfrog	riparian ponds and wetlands.
racer	riparian to flowing systems.
common loon *(SC)	herb/grass riparian on lakes.
pied-billed grebe	ponds, lakes and marsh and riparian.
horned grebe *(SM)	lakes and estuary.
red-necked grebe *(SM)	estuary.
eared grebe	estuary, lakes and marshes.
western/Clark's grebe *(SM)	lakes and estuary.
double-crested cormorant	estuary.
great egret *(SM)	beach, marsh, lakes and ponds.
black-crowned night heron *(SM)	sloughs, lakes, ponds, marshes.
tundra swan	beaches, lakes, and wet meadows.
trumpeter swan	beaches, lakes and wet meadows.
greater white-fronted goose	grass, wet meadow, estuary.
snow goose	wet meadow, estuary.
brant	estuary.
canvasback	estuary, lakes and sloughs.
redhead	estuary, lakes, ponds.
ring-necked duck	sloughs, ponds, lakes.
greater scaup	estuary, lakes.
lesser scaup	estuary, lakes, ponds.
oldsquaw	saltwater.
ruddy duck	estuary, lakes, ponds, marshes.
black-bellied plover	estuary, beach, wet meadow.
lesser golden plover	estuary and beach.
snowy plover	saltwater beach.
semipalmated plover	saltwater beach and estuary.
greater yellowlegs	estuary, lakes, ponds, marsh, meadow.
lesser yellowlegs	estuary, lakes, ponds, marsh, meadow.
solitary sandpiper	riparian stream, lakes, ponds, marsh.
willet	freshwater beaches.
wandering tattler	saltwater beaches.
whimbrel	riparian grass on saltwater beaches.
long-billed curlew *(SM)	ponds, marsh.
marbled godwit	saltwater and freshwater beaches.
ruddy turnstone	saltwater beach.
black turnstone	saltwater beach.
surfbird	saltwater beach.
red knot	estuary and saltwater beach.
sanderling	estuary and saltwater beach.
semipalmated sandpiper	estuary beach and riparian and marsh.
Baird's sandpiper	beach, lakes, ponds, and wet meadows.
pectoral sandpiper	beach, pond, marsh, wet meadow.
sharp-tailed sandpiper	marsh.
rock sandpiper	saltwater beaches.

dunlin	estuary, beach, grass and wet meadow.
buff-breasted sandpiper	beach and marsh.
short-billed dowitcher	beach and grass.
long-billed dowitcher	beach, slough, lakes, ponds and marsh.
Wilson's phalarope	estuary/beach, pond/marsh, wet meadow.
red-necked phalarope	estuary.
Franklin's gull	lake, pond, beach.
Bonaparte's gull	estuary and lakes.
Heerman's gull	estuary and beach.
mew gull	estuary, beach, river.
ring-billed gull	estuary, beach, wet meadow.
California gull	estuary/beach, river, lake/wet meadow.
herring gull	estuary, beach, river, lake.
Thayer's gull	estuary, saltwater beach.
western gull	estuary and beach.
glaucous-winged gull	estuary and beach.
glaucous gull	estuary and beach.
Caspian tern *(SM)	estuary and beach.
common tern	estuary, beach and river.
black tern *(SM)	ponds, marsh, grass and wet meadow.
rock dove	saltwater beaches.
belted kingfisher	estuary, stream, lake, marsh, pond.
horned lark	saltwater beaches.
American dipper	riparian beaches, river and stream.
red fox	wet meadow.
grizzly bear *(SE, FT)	wet meadow.
long-tailed weasel	wet meadow.
mountain lion	stream and spring riparian.
harbor seal *(SM)	estuary, beach, river.
Nuttall's cottontail	wet meadow.

Note: Other priority species dependent upon vegetated wetlands include: cackling Canada goose, dusky Canada goose, Olympic mudminnow*(SC,FC2), sandroller*(SM), cutthroat trout, Beller's ground beetle*(SC,FC2), Hatch's click beetle*(SC, FC2), long-horned leaf beetle *(SC, FC3), Oregon silverspot butterfly*(ST, SC, FT).

Other species of special concern associated with wetlands: Olympic salamander*(SM), great egret*(SM), Aleutian Canada goose*(SE, FE); yellow-billed cuckoo*(SC); pileated woodpecker*(SC); Lewis' woodpecker*(SC); ash-throated flycatcher*(SM).

Attachment 5: Eastern Washington Wetland Associated Species

Condensed from Thomas, Jack Ward. 1979. Wildlife Habitats in Managed Forests - the Blue Mountains of Oregon and Washington. U.S. Department of Agriculture. Forest Service. Agriculture Handbook No. 553:

Wetland type
- m - marsh (cattail, rush or sedge)
- d - deciduous trees and shrubs
- s - flowing waters (streams, rivers and sloughs)
- l - standing waters (ponds, lakes and reservoirs)

Trees
- M - Mature (80-159 years) plus Old Growth (160+ years)

Priority Species (Underlined are both in Thomas and WDW Priority Species)

*(State and Federal Concern Species) FE-Federal Endangered; SE-State Endangered; FT-Federal Threatened; ST-State Threatened; FC2-Federal Candidate Category 2; FP-Federal Proposed; SC-State Candidate; SM-State Monitor)

266 Species with primary breeding and or feeding in wetland systems:

Wetland and/or Buffer Components

	Wetland Type	Herbaceous	Shrub	Tree
AMPHIBIANS				
tiger salamander*(SM)	m/d	x		
long-toed salamander	m/d	x		x
tailed frog *(SM)	s	x		
Great Basin spadefoot toad	m	x	x	x
western toad	m/d	x	x	x
Woodhouse toad *(SM)	m/d	x	x	
Pacific treefrog	m/d	x	x	x
spotted frog *(SC)	m/d	x	x	x
leopard frog	m/d	x		
REPTILES				
painted turtle	s/p	x	x	x
western skink	s/l	x	x	x
ringneck snake *(SM)	d	x	x	x
common garter snake	m/d	x	x	x
side-blotched lizard	s/l	x	x	
yellow-bellied racer	s	x	x	x
gophersnake	s/l	x	x	x
western terrestrial garter snake	m/d	x	x	x
western rattlesnake	m/d	x	x	x
rubber boa	s	x	x	x

Wetland and/or Buffer Components (cont.)

BIRDS	Wetland Type	Herbaceous	Shrub	Tree
eared grebe	m	x		
pied-billed grebe	m	x		
double-crested cormorant	s	x		
American bittern	m/d	x	x	
Canada goose	m	x	x	x
mallard	m	x	x	x
gadwall	m/d	x	x	x
pintail	m	x	x	
green-winged teal	m/d	x	x	x
blue-winged teal	m	x		
cinnamon teal	m	x		
American wigeon	m/d	x	x	x
northern shoveler	m	x		
redhead	m	x		
ring-necked duck	m/d	x	x	x
lesser scaup	m	x	x	
harlequin duck	s	x	x	x
ruddy duck	m	x		
sandhill crane *(SE)	m	x	x	
Virginia rail	d	x	x	x
sora	d		x	x
American coot	m/d	x	x	x
snowy plover *(SE, FC2)	m	x		
killdeer	m	x		
common snipe	m	x		
long-billed curlew *(SM,FC2)	m	x	x	
spotted sandpiper	m	x		
willet	m	x		
American avocet	m	x		
Wilson's phalarope	m	x		
California gull	m	x	x	
ring-billed gull	m	x	x	
Franklin's gull	m	x	x	
Forster's tern *(SM)	m	x	x	
black tern *(SM)	m	x		
dipper	s	x	x	x
winter wren	s		x	x
long-billed (marsh wren)	m	x	x	
northern waterthrush	d	x	x	
common yellow throat	m	x	x	
turkey vulture *(SM)	s/l	x	x	
prairie falcon	m/d	x		
peregrine *(SE, FE)	m/d	x	x	x
rock dove	s	x		
black swift	m/d	x	x	
white-throated swift	s/l	x	x	

Wetland and/or Buffer Components (cont.)

	Wetland Type	Herbaceous	Shrub	Tree
Say's phoebe	s/l	x	x	xbarn
swallow	m/d	x		
cliff swallow	m	x	x	x
common raven	s/l	x	x	x
marsh hawk (northern harrier)	m	x	x	
blue grouse	s	x	x	x
ruffed grouse	d		x	x
sharp-tailed grouse*(SC, FC2)	s	x	x	
sage grouse *(SC, FC2)	s	x	x	
bobwhite	d	x	x	x
California quail	d	x	x	x
mountain quail	s/l	x	x	x
gray partridge	s	x		
red-necked pheasant	m/d	x	x	x
upland sandpiper *(SE)	m	x		
short-eared owl	m	x	x	
hermit thrush	s/l			xM
veery	d		x	x
water (American) pipet	m	x		
Wilson's warbler	d		x	x
bobolink	m	x	x	
western meadowlark	m/d	x	x	
dark-eyed junco	s	x	x	x
poorwill	m	x	x	x
Townsend's solitaire	s/l	x	x	x
orange-crowned warbler	d		x	x
Nashville warbler	d		x	x
Lincoln's sparrow	d	x	x	x
black-crowned night heron*(SM)	d	x	x	x
solitary sandpiper	d	x	x	x
black-chinned hummingbird	d	x	x	x
calliope hummingbird	d	x	x	x
eastern kingbird	d		x	x
willow flycatcher	s/l		x	x
gray flycatcher	s/l	x	x	x
black-billed magpie	m/d	x	x	x
gray catbird	d		x	x
sage thrasher	d		x	x
American robin	m/d	x	x	x
Swainson's thrush	s/l		x	x
loggerhead shrike *(SC)	d	x	x	x
MacGillivray's warbler	d		x	x
Treeyellow-headed blackbird	m	x	x	
red-winged blackbird	m/d	x	x	
Brewer's blackbird	m/d	x	x	x
brown-headed cowbird	m/d	x	x	x

Wetland and/or Buffer Components (cont.)

	Wetland Type	Herbaceous	Shrub	Tree
lazuli bunting	d	x	x	x
lesser goldfinch	d	x	x	
green-tailed towhee	d	x	x	x
rufous-sided towhee	d		x	x
sage sparrow *(SC)	d		x	x
chipping sparrow	d	x	x	x
Brewer's sparrow	d	x	x	x
white-crowned sparrow	d	x	x	x
fox sparrow	s/l		x	x
song sparrow	d		x	x
yellow-billed cuckoo *(SC)	d		x	x
dusky flycatcher	d	x	x	x
bushtit	d		x	x
yellow warbler	d		x	x
yellow-breasted chat	d		x	x
American goldfinch	d	x	x	x
cedar waxwing	d		x	x
American redstart	d	x	x	x
northern oriole	d		x	x
house finch	d	x	x	x
western flycatcher	d		x	x
olive-sided flycatcher	d	x	x	x
golden-crowned kinglet	s/l		x	x
ruby-crowned kinglet	d			x
yellow-rumped warbler	d			x
black-throated gray warbler	d		x	x
Townsend's warbler	d			x
western tanager	d		x	x
red crossbill	d			xM
goshawk *(SC)	d		x	xM
sharp-shinned hawk	d		x	x
Cooper's hawk	d	x	x	x
merlin*(SM)	d	x	x	xM
mourning dove	d	x	x	x
long-eared owl	d	x	x	x
rufous hummingbird	d	x	x	x
western kingbird	d	x	x	x
Hammond's flycatcher	d		x	x
western wood pewee	d		x	x
Steller's jay	d	x	x	x
common crow	d	x	x	x
varied thrush	s/l		x	x
solitary vireo	d			x
red-eyed vireo	d		x	x
warbling vireo	d		x	x
black-headed grosbeak	d	x		x

Wetland and/or Buffer Components (cont.)

	Wetland Type	Herbaceous	Shrub	Tree
evening grosbeak	d		x	x
purple finch	d	x	x	x
Cassin's finch	s/l	x	x	x
pine siskin	d	x	x	x
great blue heron	m/d	x		xM
red-tailed hawk	d	x	x	x
golden eagle *(SC)	m/d	x	x	x
bald eagle *(ST, FT)	m/d	x	x	xM
osprey *(SM)	s/l	x	x	xM
great horned owl	m/d	x	x	x
common flicker	d	x	x	x
pileated woodpecker *(SC)	s/l			xM
Lewis' woodpecker *(SC)	d	x	x	x
yellow-bellied sapsucker	d			x
Williamson's sapsucker	d			xM
hairy woodpecker	d			x
downy woodpecker	d			x
red-breasted nuthatch	s			xM
pygmy nuthatch	s			xM
wood duck	d	x	x	xM
Barrow's goldeneye	d	x	x	xM
bufflehead	d	x	x	xM
hooded merganser	d	x	x	xM
common merganser	d	x	x	xM
American kestrel	d	x	x	xM
barn owl	m/d	x	x	xM
(western) screech owl	d	x	x	xM
pygmy owl	d	x	x	x
barred owl	d	x	x	xM
saw-whet owl	d	x	x	x
Vaux's swift *(SC)	m/d			xM
ash-throated flycatcher *(SM)	s	x	x	xM
violet-green swallow	d	x	x	x
tree swallow	d	x	x	x
black-capped chickadee	d			x
mountain chickadee	d			x
chestnut-backed chickadee	d			x
brown creeper	d			xM
house wren	d	x	x	x
western bluebird *(SC)	d	x	x	x
mountain bluebird	d	x	x	x
starling	m/d	x	x	x
house sparrow	d	x	x	x
burrowing owl	s	x	x	x
belted kingfisher	s/l	x	x	x
bank swallow	m/d	x	x	

Wetland and/or Buffer Components (cont.)

	Wetland Type	Herbaceous	Shrub	Tree
rough-winged swallow	m/d	x	x	
MAMMALS				
western jumping mouse	m/d	x	x	x
small-footed myotis *(SM)	m/d	x	x	
western pipistrelle *(SM)	m/d	x	x	
western big-eared bat	m/d	x	x	x
yellow-bellied marmot	s/l	x	x	
bushy-tailed woodrat	d	x	x	x
puma (cougar)	d	x	x	x
bobcat	m/d	x	x	x
opossum	d	x	x	x
snowshoe hare	s	x	x	x
whitetail jackrabbit	s	x	x	
wolverine *(SM, FC2)	m/d	x	x	x
elk	s	x	x	x
mule deer	s/l	x	x	x
white-tailed deer	m/d	x	x	x
porcupine	s/l	x	x	x
western gray squirrel *(SC)	d			x
hoary bat	d	x	x	x
little brown myotis	m/d	x	x	xM
Yuma myotis	m/d			xM
long-eared myotis *(SM)	m/d	x	x	xM
long-legged myotis *(SM)	m/d	x	x	xM
California myotis	m/d	x	x	xM
silver-haired bat	m/d	x	x	xM
big brown bat	m/d	x	x	xM
eastern fox squirrel	s/l			xM
northern flying squirrel	s/l			x
raccoon	m/d	x	x	xM
fisher *(SC)	s/l			xM
vagrant shrew	m/d	x	x	x
dusky shrew	s/l			x
Merriam shrew *(SC)	s	x	x	
coast mole	s/l	x	x	x
pygmy rabbit *(ST, ST)	s	x	x	
yellow pine chipmunk	d	x	x	x
Townsend ground squirrel	s/l	x	x	x
W. ground squirrel *(SM)	s/l	x		
Columbian ground squirrel	s/l	x	x	x
G.-Mantled ground squirrel	s/l	x	x	x
northern pocket gopher	d	x	x	x
Great Basin pocket mouse	s/l	x	x	x
western harvest mouse	s/l	x	x	x

Wetland and/or Buffer Components (cont.)

	Wetland Type	Herbaceous	Shrub	Tree
deer mouse	m/d	x	x	x
n. grasshopper mouse *(SM)	s/l	x	x	x
heather vole	s/l	x	x	x
mountain vole	s/l	x	x	x
long-tailed vole	s/l	x	x	x
coyote	m/d	x	x	x
gray wolf *(SE, FE)	m/d	x	x	x
red fox	m/d	x	x	x
black bear	m/d	x	x	x
short-tailed weasel	d	x	x	x
long-tailed weasel	m/d	x	x	x
badger	d	x	x	x
striped skunk	m/d	x	x	
northern water shrew	s/l	x	x	x
beaver	d	x	x	x
water vole	d	x	x	x
muskrat	m/d	x	x	x
nutria	m/d	x	x	x
mink	m/d	x	x	x
river otter	m/d	x	x	x

Other eastside wetland associated Priority Species include silver-bordered bog fritillary, sandroller, westslope cutthroat trout, black-necked stilt, green-backed heron, great egret, Clark's grebe-Western grebe, horned grebe, pied-billed grebe, trumpeter swan, moose, mountain caribou, pygmy shrew.

Other species of special concern associated with wetlands: Tiger salamander*(SM), great egret*(SM), Aleutian Canada goose*(SE, FE); pileated woodpecker*(SC); Lewis' woodpecker*(SC); ash-throated flycatcher*(SM).